
DIVISION 23: HEATING, VENTILATING, AND AIR-CONDITIONING

230000 HEATING, VENTILATING, AND AIR-CONDITIONING

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SECTION 230501 – COMMON HVAC REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and General Provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Furnish labor, materials, and equipment necessary for completion of work as described in Contract Documents.
- B. It is the intent of these specifications that the systems specified herein are to be complete and operational before being turned over to the owner. During the bidding process, the contractor is to ask questions or call to the engineer's attention any items that are not shown or may be required to make the system complete and operational. Once the project is bid and the contractor has accepted the contract, it is his responsibility to furnish and install all equipment and parts necessary to provide a complete and operational system without additional cost to the owner.
- C. Furnish and install fire stopping materials to seal penetrations through fire rated structures and draft stops.
- D. Includes But Not Limited To:
 - 1. General procedures and requirements for HVAC.
- E. Related Sections:
 - 1. Section 230593: Testing, Adjusting, and Balancing for HVAC.

1.3 SUBMITTALS

- A. Substitutions: By specific designation and description, standards are established for specialties and equipment. Other makes of specialties and equipment of equal quality will be considered provided such proposed substitutions are submitted to the Architect for his approval, complete with specification data showing how it meets the specifications, at least 5 working days prior to bid opening. A list of approved substitutions will be published as an addendum.
 - 1. Submit a single copy of Manufacturer's catalog data including Manufacturer's complete specification for each proposed substitution.
 - 2. The Architect or Engineer is to be the sole judge as to the quality of any material offered as an equal.
- B. Product Data, Shop Drawings: Within 30 days after award of contract, submit 10 sets of Manufacturer's catalog data for each manufactured item.
 - 1. Literature shall include enough information to show complete compliance with Contract Document requirements.
 - 2. Mark literature to indicate specific item with applicable data underlined.

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3. Information shall include but not be limited to capacities, ratings, type of material used, guarantee, and such dimensions as are necessary to check space requirements.
 4. When accepted, submittal shall be an addition to Contract Documents and shall be in equal force. No variation shall be permitted.
 5. Even though the submittals have been accepted by the Engineer, it does not relieve the contractor from meeting all of the requirements of the plans and specifications and providing a complete and operational system.
- C. Drawings of Record: One complete sets of blue line mechanical drawings shall be provided for the purpose of showing a complete picture of the work as actually installed.
1. These drawings shall serve as work progress report sheets. Contractor shall make notations neat and legible therein daily as the work proceeds.
 2. The drawings shall be kept at the job at a location designated by the Mechanical Engineer.
 3. At completion of the project these "as-built" drawings shall be signed by the Contractor, dated, and returned to the Architect.
- D. Operating Instructions and Service Manual: The Mechanical Contractor shall prepare 2 copies of an Operation and Maintenance Manual for all mechanical systems and equipment used in this project. Manuals shall be bound in hard-backed binders and the front cover and spine of each binder shall indicate the name and location of the project. Use plastic tab indexes for all sections. Provide a section for each different type of equipment item. The following items shall be included in the manual, together with any other pertinent data. This list is not complete and is to be used as a guide.
1. Provide a master index at the beginning of the manual showing all items included.
 2. The first section of the manual shall contain:
 - a. Names, addresses, and telephone numbers of Architect, Mechanical Engineer, Electrical Engineer, General Contractor, Plumbing Contractor, Sheet Metal Contractor, and Temperature Control Contractor.
 - b. List of Suppliers which shall include a complete list of each piece of equipment used with the name, address, and telephone number of vendor.
 - c. General Description of Systems including –
 - 1) Location of all major equipment
 - 2) Description of the various mechanical systems
 - 3) Description of operation and control of the mechanical systems
 - 4) Suggested maintenance schedule
 - d. Copy of contractor's written warranty
 3. Provide a copy of approved submittal literature for each piece of equipment.
 4. Provide maintenance and operation literature published by the manufacturer for each piece of equipment which includes: oiling, lubrication and greasing data; belt sizes, types and lengths; wiring diagrams; step-by-step procedure to follow in putting each piece of mechanical equipment in operation.
 5. Include parts numbers of all replaceable items.
 6. Provide control diagram and operation sequence, along with labeling of control piping and instruments to match diagram.
 7. Include a valve chart indicating valve locations.
- E. Include air balance and/or water balance reports.

1.4 SUBMITTALS FOR COMMON HVAC REQUIREMENTS

- A. Samples: Sealer and gauze proposed for sealing ductwork.
- B. Quality Assurance / Control:
 - 1. Manufacturer's installation manuals providing detailed instructions on assembly, joint sealing, and system pressure testing for leaks.
 - 2. Specification data on sealer and gauze proposed for sealing ductwork.
- C. Quality Assurance
 - 1. Requirements: Construction details not specifically called out in Contract Documents shall conform to applicable requirements of SMACNA HVAC Duct Construction Standards.
 - 2. Pre-Installation Conference: Schedule conference immediately before installation of ductwork.

1.5 QUALITY ASSURANCE

- A. Requirements of Regulatory Agencies:
 - 1. Perform work in accordance with applicable provisions of local and state Plumbing Code, Gas Ordinances, and adoptions thereof. Provide materials and labor necessary to comply with rules, regulations, and ordinances.
 - 2. In case of differences between building codes, state laws, local ordinances, utility company regulations, and Contract Documents, the most stringent shall govern. Promptly notify Architect in writing of such differences.
- B. Applicable Specifications: Referenced specifications, standards, and publications shall be of the issues in effect on date of Advertisement for Bid.
 - 1. "Heating, Ventilating and Air Conditioning Guide" published by the American Society of Heating and Air Conditioning Engineers.
 - 2. "Engineering Standards" published by the Heating, Piping, and Air Conditioning Contractors National Association.
 - 3. "2015 International Building Code", "2015 International Mechanical Code", "2015 International Plumbing Code" and "2015 International Fire Code" as published by the International Conference of Building Officials.
 - 4. "National Electrical Code" as published by the National Fire Protection Association.
 - 5. "2015 International Energy Conservation Code".
- C. Identification: Motor and equipment name plates as well as applicable UL and AGA labels shall be in place when Project is turned over to Owner.

1.6 INSPECTIONS AND PERMITS

- A. Pay for permits, fees, or charges for inspection or other services. Local and state codes and ordinances must be properly executed without expense to Owner and are considered as minimum requirements. Local and state codes and ordinances do not relieve the Contractor from work shown that exceeds minimum requirements.

1.7 ADDITIONAL WORK:

- A. Design is based on equipment as described in the drawing equipment schedule. Any change in foundation bases, electrical wiring, conduit connections, piping, controls and openings required by alternate equipment submitted and approved shall be paid for by this division. All work shall be in accordance with the requirements of the applicable sections.

PART 2 - PRODUCTS FOR COMMON HVAC REQUIREMENTS

- A. Finishes, Where Applicable: Colors as selected by Architect.
- B. Duct Hangers:
 - 1. One inch 25 mm by 18 ga 1.27 mm galvanized steel straps or steel rods as shown on Drawings, and spaced not more than 96 inches 2 400 mm apart. Do not use wire hangers.
 - 2. Attaching screws at trusses shall be 2 inch 50 mm No. 10 round head wood screws. Nails not allowed.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Site Inspection:
 - 1. Examine premises and understand the conditions which may affect performance of work of this Division before submitting proposals for this work.
 - 2. No subsequent allowance for time or money will be considered for any consequence related to failure to examine site conditions.
- B. Drawings:
 - 1. Mechanical drawings show general arrangement of piping, ductwork, equipment, etc, and do not attempt to show complete details of building construction which affect installation. This Contractor shall refer to architectural, structural, and electrical drawings for additional building detail which affect installation of his work.
 - a. Follow mechanical drawings as closely as actual building construction and work of other trades will permit.
 - b. No extra payments will be allowed where piping and/or ductwork must be offset to avoid other work or where minor changes are necessary to facilitate installation.
 - c. Everything shown on the mechanical drawings shall be the responsibility of Mechanical Contractor unless specifically noted otherwise.
 - 2. Consider architectural and structural drawings part of this work insofar as these drawings furnish information relating to design and construction of building. These drawings take precedence over mechanical drawings.
 - 3. Because of small scale of mechanical drawings, it is not possible to indicate all offsets, fittings, and accessories which may be required. Investigate structural and finish conditions affecting this work and arrange work accordingly, providing such fittings, valves, and accessories required to meet conditions. Do not scale drawings for locations of equipment or piping. Refer to large scale dimensioned drawings for exact locations.
- C. Insure that items to be furnished fit space available. Make necessary field measurements to

ascertain space requirements including those for connections and furnish and install equipment of size and shape so final installation shall suit true intent and meaning of Contract Documents.

1. If approval is received to use other than specified items, responsibility for specified capacities and insuring that items to be furnished will fit space available lies with this Division.
2. If non-specified equipment is used and it will not fit job site conditions, this Contractor assumes responsibility for replacement with items named in Contract Documents.

3.2 PREPARATION

- A. Cut carefully to minimize necessity for repairs to existing work. Do not cut beams, columns, or trusses.
 1. Patch and repair walls, floors, ceilings, and roofs with materials of same quality and appearance as adjacent surfaces unless otherwise shown. Surface finishes shall exactly match existing finishes of same materials.
 2. Each Section of this Division shall bear expense of cutting, patching, repairing, and replacing of work of other Sections required because of its fault, error, tardiness, or because of damage done by it.
 3. Cutting, patching, repairing, and replacing pavements, sidewalks, roads, and curbs to permit installation of work of this Division is responsibility of Section installing work.

3.3 INSTALLATION

- A. Arrange pipes, ducts, and equipment to permit ready access to valves, unions, traps, starters, motors, control components, and to clear openings of doors and access panels.

3.4 STORAGE AND PROTECTION OF MATERIALS:

- A. Provide storage space for storage of materials and assume complete responsibility for losses due to any cause whatsoever. Storage shall not interfere with traffic conditions in any public thoroughfare.
- B. Protect completed work, work underway, and materials against loss or damage.
- C. Close pipe openings with caps or plugs during installation. Cover fixtures and equipment and protect against dirt, or injury caused by water, chemical, or mechanical accident.

3.5 EXCAVATION AND BACKFILL

- A. Perform necessary excavation of whatever substance encountered for proper laying of all pipes and underground ducts.
 1. Excavated materials not required for fill shall be removed from site as directed by Engineer.
 2. Excavation shall be carried low enough to allow a minimum coverage over underground piping of 5'-0" or to be below local frost level.
 3. Excess excavation below required level shall be backfilled at Contractor's expense with earth, sand, or gravel as directed by Engineer. Tamp ground thoroughly.

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4. Ground adjacent to all excavations shall be graded to prevent water running into excavated areas.

B. Backfill pipe trenches and allow for settlement.

1. Backfill shall be mechanically compacted to same density as surrounding undisturbed earth.
2. Cinders shall not be used in backfilling where steel or iron pipe is used.
3. No backfilling shall be done until installation has been approved by the Engineer.

3.6 COOPERATION

- A. Cooperate with other crafts in coordination of work. Promptly respond when notified that construction is ready for installation of work under Division 23000. Contractor will be held responsible for any delays which might be caused by his negligence or failure to cooperate with the other Contractors or crafts.

3.7 SUPERVISION

- A. Provide a competent superintendent in charge of the work at all times. Anyone found incompetent shall be removed at once and replaced by someone satisfactory, when requested by the Architect.

3.8 INSTALLATION CHECK:

- A. An experienced, competent, and authorized representative of the manufacturer or supplier of each item of equipment indicated in the equipment schedule shall visit the project to inspect, check, adjust if necessary, and approve the equipment installation. In each case, the equipment supplier's representative shall be present when the equipment is placed in operation. The equipment supplier's representative shall revisit the project as often as necessary until all trouble is corrected and the equipment installation and operation is satisfactory to the Engineer.
- B. Each equipment supplier's representative shall furnish to the Owner, through the Engineer, a written report certifying the following:
1. Equipment has been properly installed and lubricated.
 2. Equipment is in accurate alignment.
 3. Equipment is free from any undue stress imposed by connecting piping or anchor bolts.
 4. Equipment has been operated under full load conditions.
 5. Equipment operated satisfactorily.
- C. All costs for this installation check shall be included in the prices quoted by equipment suppliers.

3.9 CLEANING EQUIPMENT AND PREMISES

- A. Properly lubricate equipment before Owner's acceptance.
- B. Clean exposed piping, ductwork, equipment, and fixtures. Repair damaged finishes and leave everything in working order.

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- C. Remove stickers from fixtures and adjust flush valves.
 - D. At date of Substantial Completion, air filters shall be new, clean, and approved by Owner's representative.
 - E. Trap elements shall be removed during cleaning and flushing period. Replace trap elements and adjust after cleaning and flushing period.

3.10 TESTS

- A. No piping work, fixtures, or equipment shall be concealed or covered until they have been inspected and approved by the inspector. Notify inspector when the work is ready for inspection.
- B. All work shall be completely installed, tested as required by Contract Documents and the city and county ordinances and shall be leak-tight before the inspection is requested.
- C. Tests shall be repeated to the satisfaction of those making the inspections.
- D. Water piping shall be flushed out, tested at 100 psi and left under pressure of supply main or a minimum of 40 psi for the balance of the construction period.

3.11 WARRANTY

- A. Contractor shall guarantee work under Division 23 to be free from inherent defects for a period of one year from acceptance.
 - 1. Contractor shall repair, revise or replace any and all such leaks, failure or inoperativeness due to defective work, materials, or parts free of charge for a period of one year from final acceptance, provided such defect is not due to carelessness in operation or maintenance.
 - 2. In addition, the Contractor shall furnish all refrigeration emergency repairs, emergency service and all refrigerant required due to defective workmanship, materials, or parts for a period of one year from final acceptance at no cost to the Owner, provided such repairs, service and refrigerant are not caused by lack of proper operation and maintenance.
- B. In addition to warranty specified in General Conditions, heating, cooling, and plumbing systems are to be free from noise in operation that may develop from failure to construct system in accordance with Contract Documents.

3.12 SYSTEM START-UP, OWNER'S INSTRUCTIONS

- A. Off-Season Start-up
 - 1. If Substantial Completion inspection occurs during heating season, schedule spring start-up of cooling systems. If inspection occurs during cooling season, schedule autumn start-up for heating systems.
 - 2. Notify Owner 7 days minimum before scheduled start-up.

3. Time will be allowed to completely service, test, check, and off-season start systems. During allowed time, train Owner's representatives in operation and maintenance of system.
4. At end of off-season start-up, furnish Owner with letter confirming that above work has been satisfactorily completed.

B. Owner's Instructions

1. Instruct building maintenance personnel and Owner Representative in operation and maintenance of mechanical systems utilizing Operation & Maintenance Manual when so doing.
2. Minimum instruction periods shall be as follows –
 - a. Mechanical - Four hours.
 - b. Temperature Control - Four hours.
 - c. Refrigeration - Two hours.
3. Instruction periods shall occur after Substantial Completion inspection when systems are properly working and before final payment is made.
4. None of these instructional periods shall overlap another.

3.13 PROTECTION

- A. Do not run heat pump, air handling units, fan coil units, or other pieces of equipment used for moving supply air without proper air filters installed properly in system.
- B. The mechanical systems are not designed to be used for temporary construction heat. If any equipment is to be started prior to testing and substantial completion, such equipment will be returned to new condition with full one year warranties, from date of substantial completion after any construction use. This includes, but is not necessarily limited to: Equipment, filters, ductwork, fixtures, etc.

3.14 COMMON HVAC REQUIREMENTS:

A. INSTALLATION

1. During installation, protect open ends of ducts by covering with plastic sheet tied in place to prevent entrance of debris and dirt.
2. Make necessary allowances and provisions in installation of sheet metal ducts for structural conditions of building. Revisions in layout and configuration may be allowed, with prior written approval of Architect. Maintain required airflows in suggesting revisions.
3. Hangers And Supports:
 - a. Install pair of hangers close to each transverse joint and elsewhere as required by spacing indicated in table on Drawings.
 - b. Install upper ends of hanger securely to floor or roof construction above by method shown on Drawings.
 - c. Attach strap hangers to ducts with cadmium-plated screws. Use of pop rivets or other means will not be accepted.
 - d. Where hangers are secured to forms before concrete slabs are poured, cut off flush all nails, strap ends, and other projections after forms are removed.
 - e. Secure vertical ducts passing through floors by extending bracing angles to rest firmly on floors without loose blocking or shimming. Support vertical ducts, which

do not pass through floors, by using bands bolted to walls, columns, etc. Size, spacing, and method of attachment to vertical ducts shall be same as specified for hanger bands on horizontal ducts.

B. CLEANING

1. Clean interior of duct systems before final completion.

END OF SECTION 230501

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 230501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install identification of equipment and piping as described in Contract Documents.
- B. Mechanical Contractor shall touch-up equipment where factory paint has been damaged. Repaint entire item where more than 20 percent of the surface is involved.
- C. Primary painting of walls, ceilings, ductwork, piping and plenums is covered in the general painting section of these Contract Documents.

PART 2 - PRODUCTS

2.1 PAINT

- A. Benjamin Moore Impervo or equivalent by Paint Manufacturer approved in Section 09 900.
- B. Use appropriate primer.

2.2 LABELS

- A. Black Formica with white reveal on engraving.

2.3 CODED BANDS

- A. Using colored bands and arrows to indicate supply and return, with colored reflective tape, color code all piping installed in this contract at not more than 20-foot intervals, at equipment, at walls, etc., in accordance with ANSI Standards.
- B. Approved Manufacturers:
 - 1. Seton
 - 2. Craftmark

2.4 PIPE IDENTIFICATION

- A. In addition to the colored bands, stencil with black paint in 1/2 inch high letters a symbol and directional arrow for all fluids handled or use Seaton coded and colored pipe markers and arrows to meet ANSI Standards.

2.5 EQUIPMENT IDENTIFICATION

- A. Provide an engraved plastic plate for each piece of equipment stating the name of the item, symbol number, area served, and capacity. Label all control components with plastic embossed mechanically attached labels. Sample:
1. Supply Fan SF-1 - North Classrooms
 2. 10,000 CFM @ 2.5"

2.6 VALVE IDENTIFICATION

- A. Make a list of and tag all valves installed in this work.
1. Valve tags shall be of brass, not less than 1"x2" size, hung with brass chains.
 2. Tag shall indicate plumbing or heating service.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Engraved Plates:
1. Identify thermostats and control panels in mechanical rooms, furnaces, boilers and hot water heating specialties, duct furnaces, air handling units, electric duct heaters, and condensing units with following data engraved and fastened to equipment with screws –
 - a. Equipment mark noted on Drawings (i.e., SF-1)
 - b. Area served (i.e., North Classrooms)
 - c. Capacity (10,000 CFM @ 2.5)
- B. Stenciling:
1. Locate identifying legends and directional arrows at following points on each piping system –
 - a. Adjacent to each item of equipment and special fitting.
 - b. At point of entry and exit where piping goes through wall.
 - c. On each riser and junction.
 - d. Every 50 feet on long continuous lines.
 2. Gas, & Valve Identification –
 - a. Identify specific pipe contents by stenciling pipe with written legend and placing of arrows to indicate direction of flow.
- C. Painting:
1. Background Color - Provide by continuous painting of piping.

Symbol	Name	Color
NG	Natural Gas	Yellow
AIR	Air	Blue

2. Identification stenciling and flow arrows shall be following colors for proper contrast:

Arrows & ID Stenciling Color Shade of Pipe

White
Black

Red, Grays, & black
Yellows, Oranges, Greens, & White

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Division 23 0501 - Common HVAC Requirements and Basic Mechanical Materials and Methods Sections apply to work of this section.

1.2 SUMMARY SCOPE

- A. This Section includes TAB to produce design objectives for the following:
 - 1. Air Systems.
 - a. Furnaces.
 - b. Exhaust Fans.

1.3 SUBMITTALS

- A. Agency Data:
 - 1. Submit proof that the proposed testing, adjusting, and balancing agency meets the qualifications specified below. The firm or individuals performing the work herein specified may not be the installing firm.
- B. Engineer and Technicians Data:
 - 1. Submit proof that the Test and Balance Engineer assigned to supervise the procedures, and the technicians proposed to perform the procedures meet the qualifications specified below.
- C. Procedures and Agenda: Submit a synopsis of the testing, adjusting, and balancing procedures and agenda proposed to be used for this project.
- D. Sample Forms: Submit sample forms, if other than those standard forms prepared by the AABC or NEBB are proposed.
- E. Certified Reports: Submit testing, adjusting, and balancing reports bearing the seal and signature of the Test and Balance Engineer. The reports shall be certified proof that the systems have been tested, adjusted, and balanced in accordance with the referenced standards; are an accurate representation of how the systems have been installed; are a true representation of how the systems are operating at the completion of the testing, adjusting, and balancing procedures; and are an accurate record of all final quantities measured, to establish normal operating values of the systems. Follow the procedures and format specified below.
 - 1. Draft Reports: Upon completion of testing, adjusting, and balancing procedures, prepare draft reports on the approved forms. Draft reports may be hand written, but must be complete, factual, accurate, and legible. Organize and format draft reports in the same manner specified for the final reports. Submit 2 complete sets of draft reports. Only 1 complete set of draft reports will be returned.

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2. Final Report: Upon verification and approval of draft reports, prepare final reports, type written, and organized and formatted as specified below. Submit 4 complete sets of final reports.
 3. Report Format: Report forms shall be those standard forms prepared by the referenced standard for each respective item and system to be tested, adjusted, and balanced. Bind report forms complete with schematic systems diagrams and other data. Divide the contents of the binder into the below listed divisions, separated by divider tabs:
 - a. General Information and Summary
 - b. Air Systems
 - c. Temperature Control System Verification.
- F. Report Contents: Provide the following minimum information, forms, and data:
1. General information and Summary: Inside cover sheet to identify testing, adjusting, balancing agency, Contractor, Owner, Engineer, and Project. Include addresses and contact names and telephone numbers. Also include a certification sheet containing the seal and name, address, telephone number, and signature of the Certified Test and Balance Engineer. Include in this division a listing of the instrumentation used for the procedures along with the instrument calibration sheet.
 2. The remainder of the report shall contain the appropriate forms containing as a minimum, the information indicated on the standard report forms prepared by the AABC or NEBB, for each respective item and system. Prepare a schematic diagram for each item of equipment and system to accompany each respective report form. The report shall contain the following information, and all other data resulting from the testing, adjusting, and balancing work:
 - a. All nameplate and specification data for all air handling equipment and motors.
 - b. Actual metered running amperage for each phase of each motor on all pumps and air handling equipment.
 - c. Actual metered voltage at air handling equipment (phase-to-phase for all phases).
 - d. Fan RPM for each piece of air handling equipment.
 - e. Total actual CFM being handled by each piece of air handling equipment.
 - f. Actual CFM of systems by rooms.
 3. Certify that all smoke and fire dampers operate properly and can be reset under actual system operating conditions.
- G. Calibration Reports:
1. Submit proof that all required instrumentation has been calibrated to tolerances specified in the referenced standards, within a period of six months prior to starting the project.

1.4 CERTIFICATION

- A. Agency Qualifications:
1. Employ the services of a certified testing, adjusting, and balancing agency meeting the qualifications specified below, to be the single source of responsibility to test, adjust, and balance the building mechanical systems identified above, to produce the design objectives. Services shall include checking installations for conformity to design, measurement, and establishment of the fluid quantities of the mechanical systems as

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- required to meet design specifications, recording and reporting the results, and operation of all systems to demonstrate satisfactory performance to the owner.
2. The testing, adjusting, and balancing agency certified by National Environmental Balancing Bureau (NEBB) or Associated Air Balance Council (AABC) in those testing and balancing disciplines required for this project, and having at least one person certified by NEBB or AABC as a Test and Balance supervisor, and a registered professional mechanical engineer, licensed in the state where the work will be performed.

B. Codes and Standard:

1. NEBB: "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."
2. AABC: "National Standards for Total System Balance."
3. ASHRAE: ASHRAE Handbook, 1984 Systems Volume, Chapter 37, Testing, Adjusting, and Balancing.

1.5 PROJECT CONDITIONS

- A. Systems Operation: Systems shall be fully operation and clean prior to beginning procedures.

1.6 SEQUENCING AND SCHEDULING

- A. Test, adjust, and balance the air systems before hydronic, steam, and refrigerant systems within +10% to -5% of contract requirements.
- B. The report shall be approved by the Engineer. Test and balance shall be performed prior to substantial completion.

PART 2 - NOT USED

PART 3 - EXECUTION

3.1 PRELIMINARY PROCEDURES FOR AIR SYSTEM BALANCING

- A. Before operating the system, perform these steps.
 1. Obtain design drawings and specifications and become thoroughly acquainted with the design intent.
 2. Obtain copies of approved shop drawings of all air handling equipment, outlets (supply, return, and exhaust) and temperature control diagrams.
 3. Compare design to installed equipment and field installations.
 4. Walk the system from the system air handling equipment to terminal units to determine variations of installation from design.
 5. Check filters for cleanliness and to determine if they are the type specified.
 6. Check dampers (both volume and fire) for correct and locked position. Check automatic operating and safety controls and devices to determine that they are properly connected, functioning, and at proper operating setpoint.
 7. Prepare report test sheets for both fans and outlets. Obtain manufacturer's outlet factors and recommended procedures for testing. Prepare a summation of required outlet volumes to permit a cross-check with required fan volumes.

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8. Determine best locations in main and branch ductwork for most accurate duct traverses.
 9. Place outlet dampers in the full open position.
 10. Prepare schematic diagrams of system "As-Built" ductwork and piping layouts to facilitate reporting.
 11. Lubricate all motors and bearings.
 12. Check fan belt tension.
 13. Check fan rotation.

3.2 MEASUREMENTS

- A. Provide all required instrumentation to obtain proper measurements, calibrated to the tolerances specified in the referenced standards. Instruments shall be properly maintained and protected against damage.
- B. Provide instruments meeting the specifications of the referenced standards.
- C. Use only those instruments which have the maximum field measuring accuracy and are best suited to the function being measured.
- D. Apply instrument as recommended by the manufacturer.
- E. Use instruments with minimum scale and maximum subdivisions and with scale ranges proper for the value being measured.
- F. When averaging values, take a sufficient quantity of readings which will result in a repeatability error of less than 5%. When measuring a single point, repeat readings until 2 consecutive identical values are obtained.
- G. Take all readings with the eye at the level of the indicated value to prevent parallax.
- H. Use pulsation dampeners where necessary to eliminate error involved in estimating average of rapidly fluctuation readings.
- I. Take measurements in the system where best suited to the task.

3.3 PERFORMING TESTING, ADJUSTING, AND BALANCING

- A. Perform testing and balancing procedures on each system identified, in accordance with the detailed procedures outlined in the referenced standards. Balancing of the air systems and hydronic systems shall be achieved by adjusting the automatic controls, balancing valves, dampers, air terminal devices, and the fan/motor drives within each system.
- B. Cut insulation, ductwork, and piping for installation of test probes to the minimum extent necessary to allow adequate performance of procedures.
- C. Patch insulation, ductwork, and housings, using materials identical to those removed.
- D. Seal ducts and piping, and test for and repair leaks.

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- E. Seal insulation to re-establish integrity of the vapor barrier.
 - F. Adjust timing relays of environmental equipment motor reduced voltage starters to the optimum time period for the motor to come up to the maximum reduced voltage speed and then transition to the full voltage speed to prevent damage to motor, and to limit starting current spike to the lowest possible and practical.
 - G. Mark equipment settings, including damper control positions, valve indicators, fan speed control levers, and similar controls and devices, to show final settings. Mark with paint or other suitable, permanent identification materials.
 - H. Retest, adjust, and balance systems subsequent to significant system modifications, and resubmit test results.

3.4 RECORD AND REPORT DATA

- A. Record all data obtained during testing, adjusting, and balancing in accordance with, and on the forms recommended by the referenced standards, and as approved on the sample report forms.
- B. Prepare report of recommendations for correcting unsatisfactory mechanical performances when system cannot be successfully balanced.
- C. Report shall be certified and stamped by a registered professional mechanical engineer employed by the agency and licensed in the state where the work will be performed.
- D. Engineer is to provide a floor plan and test and balance contractor to include the plan in test and balance report and identify actual cfm on drawing or number the diffusers to match report.

3.5 DEMONSTRATION

- A. If requested, testing, adjusting, and balancing agency shall conduct any or all of the field tests in the presence of the engineer.
- B. Agency shall include a maximum of one (1) call back to the project within the one year warranty period to make additional adjustments if requested by the engineer.

END OF SECTION 230593

SECTION 230712 - MECHANICAL INSULATION AND FIRE STOPPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 230501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install mechanical insulation and fire stopping as described in Contract Documents including but not limited to the following:
 1. Ductwork Insulation
 2. Refrigerant Piping
 3. Fire Stopping

1.3 QUALITY ASSURANCE

- A. Insulation shall have composite (insulation, jacket or facing and adhesive used to adhere facing or jacket to insulation) fire and smoke hazard ratings as tested by Procedure ASTM E-84, NFPA 255 and UL 723 not exceeding: Flame Spread of 25 and Smoke Developed of 50.
- B. Insulation Contractor shall certify in writing, prior to installation, that all products to be used will meet the above criteria.
- C. Accessories, such as adhesives, mastics, cements, and tapes, for fittings shall have the same component ratings as listed above.
- D. Products, or their shipping cartons, shall bear a label indicating that flame and smoke ratings do not exceed above requirements.
- E. Any treatment of jacket or facings to impart flame and smoke safety shall be permanent.
- F. The use of water-soluble treatments is prohibited.

END OF SECTION 230712

SECTION 230716 - DUCTWORK INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install insulation on air ducts outside building insulation envelope as described in Contract Documents.
- B. Furnish and install insulation on fresh air ducts and combustion air ducts within building insulation envelope as described in Contract Documents.
- C. Furnish and install insulation on other air ducts where indicated on Drawings.

PART 2 - PRODUCTS

2.1 INSULATION

- A. 1-1/2 inch thick fiberglass with aluminum foil scrim kraft facing and have a density of one lb/cu ft.
- B. Approved Manufacturers:
 - 1. Manville Microlite FSK
 - 2. CSG Type IV standard duct insulation
 - 3. Owens-Corning FRK
 - 4. Knauf (Duct Wrap FSK)

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct wrap in accordance with Manufacturer's recommendations.
- B. Do not compress insulation except in areas of structural interference.
- C. Completely seal joints.

END OF SECTION 230716

SECTION 230717 – ROUND SUPPLY DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install round supply duct insulation as described in Contract Documents.

1.3 QUALITY ASSURANCE

- A. Insulation shall be UL rated with FSK (foil-skrim-kraft) facing.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

- A. Fiberglass blanket insulation
- B. Approved Manufacturers:
 1. Johns-Manville R-4 Microlite (R-4 does not include the vapor barrier material).
 2. Owens-Corning faced duct wrap insulation FRK-25 ED-150
 3. Certainteed Standard Duct Wrap.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Insulate round air supply ducts.
- B. Facing shall overlap 2" at joints and shall be secured with outward clinch staples on 4" centers.
- C. Ducts over 30" in width shall have spot application of adhesive, weld pins or metal screws and caps on not more than 18" centers applied to underside.
- D. 3" wide vapor barrier paper shall be applied over seams and sealed with vapor barrier adhesive.
- E. Insulate attenuators.
- F. Insulate high and low pressure flex ducts.

END OF SECTION 230717

SECTION 230718 - DUCT LINING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install acoustic lining in following above ground metal ductwork as described in Contract Documents unless detailed otherwise:
 - 1. Outside air
 - 2. Supply air
 - 3. Return air
 - 4. Mixed air
 - 5. Transfer air
 - 6. Relief air
 - 7. Elbows, fittings, and diffuser drops greater than 12 inches in length.
- B. Furnish and install lining in concrete underfloor boxes.

1.3 SYSTEM DESCRIPTION

- A. Duct dimensions shown on Drawings are for free area inside insulation. Allowance must be made for insulation, where applicable.

1.4 RATINGS:

- A. Material shall have maximum air friction correction factor of 1.10 at 1000 FPM velocity and have a minimum sound absorption coefficient NRC of .60.

PART 2 - PRODUCTS

2.1 DUCT LINER

- A. One inch thick, 1-1/2 lb density fiberglass, factory edge coated.
- B. Duct lining materials are to meet the requirements of UL 181 for mold, humidity, and erosion resistance.
- C. Approved Manufacturers:
 - 1. Certainteed Ultralite 150 Certa Edge Coat
 - 2. Knauf - Type M
 - 3. Manville - Lina-Coustic
 - 4. Owen Corning Fiberglas - Aeroflex

2.2 ADHESIVE

- A. Water Base Type:
 - 1. Cain - Hydrotak
 - 2. Duro Dyne - WSA
 - 3. Kingco - 10-568
 - 4. Miracle - PF-101
 - 5. Mon-Eco - 22-67
 - 6. Techno Adhesive - 133

- B. Solvent Base (non-flammable) Type:
 - 1. Cain - Safetak
 - 2. Duro Dyne - FPG
 - 3. Kingco - 15-137
 - 4. Miracle - PF-91
 - 5. Mon-Eco - 22-24
 - 6. Techno Adhesive - 'Non-Flam' 106

- C. Solvent Base (flammable) Type:
 - 1. Cain - HV200
 - 2. Duro Dyne - MPG
 - 3. Kingco - 15-146
 - 4. Miracle - PF-96
 - 5. Mon-Eco - 22-22
 - 6. Techno Adhesive - 'Flammable' 106

2.3 FASTENERS

- A. Adhesively secured fasteners not allowed.

- B. Approved Manufacturers:
 - 1. AGM Industries Inc - "DynaPoint" Series DD-9 pin
 - 2. Cain
 - 3. Duro Dyne
 - 4. Omark dished head "Insul-Pins"
 - 5. Grip nails may be used if each nail is installed by "Grip Nail Air Hammer" or by "Automatic Fastener Equipment" in accordance with Manufacturer's recommendations.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install mat finish surface on air stream side. Secure insulation to cleaned sheet metal duct with continuous 100% coat of adhesive and with 3/4 inch long mechanical fasteners 12 inches on center maximum unless detailed otherwise on Drawings. Pin all duct liner.

- B. Accurately cut liner and thoroughly coat ends with adhesive. Butt joints tightly. Top and bottom sections of insulation shall overlap sides. If liner is all one piece, folded corners shall be tight against metal. Ends shall butt tightly together.

-
- C. In casings and plenums further contain insulation with wire mesh.

3.2 FIELD QUALITY CONTROL

- A. If insulation is installed without longitudinal and end joints butted together, installation will be rejected and work removed and replaced with work that conforms to this Specification.
- B. Insulation shall be installed in accordance with Duct Liner Application Standard SMACNA Manual 15.

3.3 ADJUSTING, CLEANING

- A. Keep duct liner clean and free from dust. At completion of project, vacuum duct liner if it is dirty or dusty.

END OF SECTION 230718

SECTION 230720 - REFRIGERANT PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install insulation on above ground refrigerant suction piping and fittings, including thermal bulb, from thermal expansion valve as described in Contract Documents.

1.3 QUALITY ASSURANCE

- A. Insulation shall have flame-spread rating of 25 or less and a smoke density rating of 50 or less as tested by ASTM E-84 method.
- B. Ratings:
 - 1. Upper rating of =210 deg. F.
 - 2. Lower rating of -110 deg. F.
 - 3. UV stabilized for ten year life.
 - 4. Thermal conductivity of 0.24.
 - 5. Water vapor transmission of .03 perms per inch.
 - 6. Material to be polyolefin food grade.

PART 2 - PRODUCTS

2.1 FLEXIBLE FOAMED PIPE INSULATION

- A. Thickness:
 - 1. 1/2 inch for one inch outside diameter and smaller pipe.
 - 2. 3/4 inch for 1-1/8 through 2 inch outside diameter pipe.
 - 3. One inch for 2-1/8 inches outside diameter and larger pipe (two layers of 1/2 inch).
 - 4. One inch sheet for fittings as recommended by Manufacturer.
- B. Approved Manufacturers:
 - 1. Armaflex
 - 2. Halstead "Insul-tube"
 - 3. Rubatex
 - 4. Therma-Cel

2.2 JOINT SEALER

- A. Approved Manufacturers:
 - 1. Armaflex 520
 - 2. BFG Construction Adhesive #105
 - 3. Therma-Cel 950.

2.3 MANUFACTURED UNITS

- A. Nominal 3/4" wall thickness
- B. Approved Manufacturers:
 - 1. ImcoLock Pipe Insulation
 - 2. or approved equal

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install insulation in snug contact with pipe and in accordance with Manufacturer's recommendations.
- B. Insulation shall be slipped onto pipe prior to connection or applied after pipe is installed, at contractor's option.
- C. Close butt joints and miter joints.
 - 1. Approved Manufacturers:
 - a. IMCOA's Fuse-Seal joining system
 - b. or factory approved contact adhesive
- D. Insulation shall be installed according to manufacturer's recommended procedures.
- E. Exterior exposed Insulation shall be finished with two coats of factory approved finish. Color shall be selected by the Owner's representative.
- F. Stagger joints on layered insulation.
- G. Slip insulation on tubing before tubing sections and fittings are assembled keeping slitting of insulation to a minimum.
- H. Seal joints in insulation.
- I. Insulate flexible pipe connectors.
- J. Insulate thermal expansion valves with insulating tape.
- K. Insulation exposed outside building shall have "slit" joint seams placed on bottom of pipe.
- L. Insulate fittings with sheet insulation and as recommended by Manufacturer.

END OF SECTION 230720

SECTION 230800 – FIRE STOPPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install fire stopping as described in Contract Documents.

1.3 QUALITY ASSURANCE

- A. Fire stopping material shall meet ASTM E814, E84 and be UL listed.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

- A. Material shall be flexible, long lasting, intumescent acrylic seal to accommodate vibration and building movement.
- B. Caulk simple penetrations with gaps of 1/4" or less with:
 - 1. Dow Corning Fire Stop Sealant
 - 2. Pensil 300
- C. Caulk multiple penetrations and/or penetrations with gaps in excess of 1/4" with:
 - 1. Dow Corning Fire Stop Foam
 - 2. Pensil 200
 - 3. IPC flame safe FS-1900
 - 4. Tremco "Tremstop 1A"

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Follow manufacturer's installation instructions explicitly.
- B. Seal penetrations of ductwork, piping, and other mechanical equipment through one-hour and two-hour rated partitions as shown on Architectural and Mechanical Drawings.
- C. Install fire stopping material on clean surfaces to assure adherence.

END OF SECTION 230800

SECTION 232300 - REFRIGERANT PIPING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install piping for refrigeration systems as described in Contract Documents.

1.3 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Refrigerant piping shall be installed by a refrigeration contractor licensed by State.

PART 2 - PRODUCTS

2.1 REFRIGERANT PIPING

- A. Meet requirements of ASTM B 280-88, "Specification for Seamless Copper Tube for Air Conditioning & Refrigeration Field Service", hard drawn straight lengths.
- B. Do not use pre-charged refrigerant lines.

2.2 REFRIGERANT FITTINGS

- A. Wrought copper with long radius elbows.
- B. Approved Manufacturers:
 - 1. Mueller Streamline
 - 2. Nibco Inc
 - 3. Grinnell
 - 4. Elkhart Products Corp

2.3 CONNECTION MATERIAL

- A. Brazing Rods:
 - 1. Copper to Copper Connections:
 - 2. AWS Classification BCuP-4 Copper Phosphorus (6% silver).
 - 3. AWS Classification BCuP-5 Copper Phosphorus (15% silver).
 - 4. Copper to Brass or Copper to Steel Connections:
 - 5. AWS Classification BAg-5 Silver (45% silver).
 - 6. Do not use rods containing Cadmium.

2.4 FLUX

- A. Approved Manufacturers:
 - 1. "Stay-Silv white brazing flux" by J W Harris Co
 - 2. High quality silver solder flux by Handy & Harmon

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Do not install refrigerant piping underground or in tunnels.
- B. Slope suction lines down toward compressor one inch/10 feet. Locate traps at vertical rises against flow in suction lines.
- C. Refrigeration system connections shall be copper-to-copper, copper-to-brass, or copper-to-steel type properly cleaned and brazed with specified rods. Use flux only where necessary.
 - 1. No soft solder (tin, lead, antimony) connections will be allowed in system.
- D. Braze valve, sight glass, and flexible connections.
- E. Circulate dry nitrogen through tubes being brazed to eliminate formation of copper oxide during brazing operation.

3.2 FIELD QUALITY CONTROL

- A. Make evacuation and leak tests in presence of Architect's Engineer after completing refrigeration piping systems. Positive pressure test will not suffice for procedure outlined below.
 - 1. Draw vacuum on each entire system with vacuum pump to 200 microns using vacuum gauge calibrated in microns. Do not use cooling compressor to evacuate system nor operate it while system is under high vacuum. Isolate compressor from system piping using shut-off valves prior to pulling vacuum.
 - 2. Break vacuum with freon to be used and re-establish vacuum test. Vacuum shall hold for 24 hours at 200 microns without compressor running.
 - 3. Conduct tests at 70 deg F ambient temperature minimum.
 - 4. Do not run systems until above tests have been made and systems started up as specified. Inform Owner's Representative of status of systems at time of final inspection and schedule start-up and testing if prevented by outdoor conditions before this time.
 - 5. After testing, fully charge system with refrigerant and conduct test with Halide Leak Detector.

END OF SECTION 232300

SECTION 232310 - REFRIGERANT SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install refrigeration specialties as described in Contract Documents except for expansion valves on 2 through 5 ton condensing units.

PART 2 - PRODUCTS

2.1 EXPANSION VALVES

- A. For pressure type distributors, externally equalized with stainless steel diaphragm, and same refrigerant in thermostatic elements as in system.
- B. Size valves to provide full rated capacity of cooling coil served. Coordinate selection with evaporator coil and condensing unit.
- C. Approved Manufacturers:
 - 1. Alco
 - 2. Henry
 - 3. Mueller
 - 4. Parker
 - 5. Singer
 - 6. Sporlan

2.2 FILTER-DRIER

- A. On lines 3/4 inch outside diameter and larger, filter-drier shall be replaceable core type with Schraeder type valve.
- B. On lines smaller than 3/4 inch outside diameter, filter-drier shall be sealed type using flared copper fittings.
- C. Size shall be full line size.
- D. Approved Manufacturers:
 - 1. Alco
 - 2. Mueller
 - 3. Parker
 - 4. Sporlan
 - 5. Virginia

2.3 SIGHT GLASS

- A. Combination moisture and liquid indicator with protection cap.
- B. Sight glass shall be full line size.
- C. Sight glass connections shall be solid copper or brass, no copper-coated steel sight glasses allowed.
- D. Approved Manufacturers:
 - 1. Alco
 - 2. Mueller
 - 3. Parker
 - 4. Superior
 - 5. Virginia

2.4 MANUAL REFRIGERANT SHUT-OFF VALVE

- A. Ball valves designed for refrigeration service and full line size.
- B. Valve shall have cap seals.
- C. Valves with hand wheels are not acceptable.
- D. Provide service valve on each liquid and suction line at compressor.
- E. If service valves come as integral part of condensing unit, additional service valves shall not be required.
- F. Approved Manufacturers:
 - 1. ConBraCo (Apollo)
 - 2. Henry
 - 3. Mueller
 - 4. Superior
 - 5. Virginia

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install valves and specialties in accessible locations. Install refrigeration distributors and suction outlet at same end of coil.

END OF SECTION 232310

SECTION 233114 - LOW-PRESSURE STEEL DUCTWORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 230501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install above-grade ductwork and related items as described in Contract Documents.

PART 2 - PRODUCTS

2.1 DUCTS

- A. Fabricate of zinc-coated lockforming quality steel sheets meeting requirements of ASTM 653A/653M, "Specification for Sheet Steel Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock Forming Quality", with G 60 coating.
- B. Use of aluminum, non-metallic, or round ducts is not permitted. [Specification writer: Use of aluminum ducts in areas with high chlorine content (eg.: ventilation for pools, spas, etc.) should be considered on a per job basis.]

2.2 DUCT JOINTS

- A. Ducts with sides up to and including 36 inches shall be as detailed in the SMACNA manual.
- B. Duct sizes over 36 inches shall be fabricated using SMACNA T-24 flange joints or pre-fabricated systems as follows:
 - 1. Ducts with sides over 36 inches to 48 inches:
 - a. transverse duct joint system by Ductmate/25, Nexus, Ward, or WDCI (Lite) (SMACNA "E" or "G" Type connection).
 - 2. Ducts 48 inches & larger:
 - a. Ductmate/35, Nexus, or WDCI (Heavy) (SMACNA "J" Type connection).
 - 3. Approved Manufacturers:
 - a. Ductmate Industries Inc, 10760 Bay Meadows Drive, Sandy, UT 84092 (801) 571-5308
 - b. Nexus, Exanno Corp, P O Box 729, Buffalo, NY 14206 (716) 849-0545
 - c. Ward Industries Inc, 1661 Lebanon Church Road, Pittsburg, PA 15236 (800) 466-9374
 - d. WDCI, P O Box 10868, Pittsburg, PA 15236 (800) 245-3188

2.3 ACCESS DOORS IN DUCTS

- A. At each manual outside air damper and at each motorized damper, install factory built insulated access door with hinges and sash locks. Locate doors within 6 inches of installed

dampers. Construction shall be galvanized sheet metal, 24 ga minimum.

- B. Fire and smoke damper access doors shall have a minimum clear opening of 12" x 12" or as specified on Drawings to easily service fire or smoke damper. Doors shall be within 6 inches of fire and smoke dampers and in Mechanical Room if possible.
- C. Identify each door with 1/2" high letters reading "smoke damper" or "fire damper".
- D. Approved Manufacturers:
 - 1. AirBalance - Fire/Seal #FSA 100
 - 2. Air Control Products - HAD-10
 - 3. Cesco-Advanced Air - HAD-10
 - 4. Elgen - Model 85 A
 - 5. Kees Inc - ADH-D.
 - 6. Louvers & Dampers - #SMD-G-F
 - 7. Nailor-Hart Industries Inc - Series 0831
 - 8. National Controlled Air Inc - Model AD-FL-1

2.4 FLEXIBLE EQUIPMENT CONNECTIONS

- A. 30 oz closely woven UL approved glass fabric, double coated with neoprene.
- B. Fire retardant, waterproof, air-tight, resistant to acids and grease, and withstand constant temperatures of 250 deg F.
- C. Approved Manufacturers:
 - 1. Cain - N-100
 - 2. Duro Dyne - MFN
 - 3. Elgen - ZLN
 - 4. Ventfabrics - Ventglas

2.5 CONCEALED CEILING DAMPER REGULATORS

- A. Approved Manufacturers:
 - 1. Cain
 - 2. Duro Dyne
 - 3. Metco Inc
 - 4. Vent-Lock - #666
 - 5. Young - #303

2.6 VOLUME DAMPERS

- A. In Main Ducts:
 - 1. 16 gauge galvanized steel, opposed blade type with 3/8 inch pins and end bearings. Blades shall have 1/8 inch clearance all around.
 - 2. Damper shall operate within acoustical duct liner.
 - 3. Provide channel spacer equal to thickness of duct liner.
 - 4. Approved Manufacturers:
 - a. Air Balance - Model AC-2

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- b. Air Control Products - CD-OB
 - c. American Warming - VC-2-AA
 - d. Greenheck - VCD-1100
 - e. NCA, Safe Air
 - f. Vent Products - 5100

B. In Sheet Metal Branch Ducts:

- 1. Extruded aluminum, opposed blade type. When in open position, shall not extend beyond damper frame.
- 2. Maximum blade length 12 inches.
- 3. Damper Regulator shall be concealed type with operation from bottom or with 90 deg miter gear assembly from side.
- 4. Approved Manufacturers:
 - a. Air Control Products - TCD-OB
 - b. Air Guide - OB
 - c. Arrow - OBDAF-207
 - d. CESCO - CDA
 - e. Reliable Metals - OBD-RO
 - f. Tuttle & Bailey - A7RDDM
 - g. Safe Air
 - h. Young - 820-AC

- C. Dampers above removable ceiling and in Mechanical Rooms shall have locking quadrant on bottom or side of duct. Otherwise, provide concealed ceiling damper regulator and cover plate.

2.7 MOTORIZED OUTSIDE AIR DAMPERS

A. Damper Blades:

- 1. 18 gauge galvanized steel or equivalent aluminum with replaceable rubber blade edges, 9 inches wide maximum.
- 2. End seals shall be flexible metal compression type.
- 3. Opposed blade type.

- B. Make provision for damper actuators and actuator linkages to be mounted external of air flow.

C. Approved Manufacturers & Models:

- 1. Air Balance - AC-2
- 2. American Warming - VC-2-AAVA
- 3. Arrow - OBDAF-207
- 4. Greenheck - VCD-2100
- 5. Honeywell - D641
- 6. Johnson - D1300
- 7. Louvers & Dampers - TSD400
- 8. Ruskin - CD36 or CD60
- 9. Safe Air - 610
- 10. Vent Products - 5800

2.8 BACKDRAFT DAMPER

- A. Backdraft blades shall be nonmetallic and shall be neoprene coated fiberglass.
- B. Stop shall be galvanized steel screen or expanded metal, 1/2 inch mesh.
- C. Frame shall be galvanized steel or extruded aluminum alloy.
- D. Approved Models & Manufacturers:
 - 1. Air Control Products - FBD
 - 2. American Warming - BD-15
 - 3. CESCO - FBD 101
 - 4. Ruskin - NMS2
 - 5. Safe Air

2.9 DUCT HANGERS

- A. 1" x 18 gauge galvanized steel straps or steel rods as shown on Drawings, and spaced not more than 8 feet apart. Do not use wire hangers.
- B. Attaching screws at trusses shall be 1-1/2 inch No. 10 round head wood screws. Nails not allowed.

2.10 DUCT SEALER

- A. Cain - Duct Butter or Butter Tak
- B. Design Polymerics - DP 1010
- C. DSC - Stretch Coat
- D. Duro Dyne - S2
- E. Hardcast - #601 Iron-Grip or Peel-N-Seal Tape
 - 1. Kingco - 15-325
 - 2. Mon-Eco - 44-41
 - 3. Trans-Continental Equipment Co - Multipurpose Duct Sealant
 - 4. United - Sheet Metal duct-sealer

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Ducts:
 - 1. Straight and smooth on inside with joints neatly finished unless otherwise directed.
 - 2. Duct panels through 48 inch dimension having acoustic duct liner need not be crossbroken or beaded.
 - 3. Crossbreak unlined ducts and duct panels larger than 48 inch or bead 12 inches on center.

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4. Securely anchor ducts to building structure with specified duct hangers attached with screws. Do not hang more than one duct from a duct hanger.
 5. Brace and install ducts so they shall be free of vibration under all conditions of operation.
 6. Ducts shall not bear on top of structural members.
 7. Make duct take-offs to branches, registers, grilles, and diffusers as detailed on Drawings.
 8. Ducts shall be large enough to accommodate inside acoustic duct liner. Dimensions shown on Drawings are net clear inside dimensions after duct liner has been installed.
 9. Properly flash where ducts protrude above roof.
 10. Install internal ends of slip joints in direction of flow. Make joints air tight using specified duct sealer.
 11. Cover horizontal and longitudinal joints on exterior ducts with two layers of Hardcast tape installed with Hardcast HC-20 adhesive according to Manufacturer's recommendations.
 12. Paint ductwork visible through registers, grilles, and diffusers flat black.
- B. Install flexible inlet and outlet duct connections to each furnace, fan, fan coil unit, and air handling unit.
- C. Install concealed ceiling damper regulators.
1. Paint cover plates to match ceiling tile.
 2. Damper regulators will not be required for dampers located directly above removable ceilings or in Mechanical Rooms.
- D. Provide each take-off with an adjustable volume damper to balance that branch.
1. Anchor dampers securely to duct.
 2. Install dampers in main ducts within insulation.
 3. Dampers in branch ducts shall fit against sheet metal walls, bottom and top of duct, and be securely fastened. Cut duct liner to allow damper to fit against sheet metal.
 4. Where concealed ceiling damper regulators are installed, provide a cover plate.
- E. Install grilles, registers, and diffusers. Level floor registers and anchor securely into floor.
- F. Air Turns:
1. Permanently installed, consisting of single thickness curved metal blades with one inch straight trailing edge to permit air to make abrupt turn without appreciable turbulence, in 90 degree elbows of above ground supply and return ductwork.
 2. 4-1/2 inch wide minimum vane rail. Do not use junior vane rails.
 3. Double thickness vanes not acceptable.
 4. Quiet and free from vibration when system is in operation. See SMACNA Manual
- G. Install motorized dampers

END OF SECTION 233114

SECTION 233346 - FLEX DUCT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 230501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install supply air branch duct runouts to diffusers as described in Contract Documents.

PART 2 - PRODUCTS

2.1 DUCTS

- A. Formable, flexible, circular duct which shall retain its cross-section, shape, rigidity, and shall not restrict air flow after bending.
- B. Nominal 1-1/2 inches thick, 3/4 lb/cu ft density fiberglass insulation with air-tight, polyethylene or polyester core, sheathed in seamless vapor barrier jacket factory installed over flexible assembly.
- C. Assembly, including insulation and vapor barrier, shall meet Class I requirement of NFPA 90A and be UL 181 rated, with flame spread of 25 or less and smoke developed rating of 50 or under.
- D. Length of flexible ductwork shall not exceed 8'-0".

2.2 APPROVED MANUFACTURERS

- A. ANCO-FLEX - 4625
- B. Flex-Aire - PF/UPC #090
- C. Hart & Cooley - F114
- D. Thermaflex - G-KM

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct in fully extended condition free of sags and kinks.
- B. Make duct connections by coating exterior of duct collar for 3 inches with duct sealer and securing duct in place over sheet metal collar with 1/2 inch wide metal cinch bands and sheet

metal screws.

END OF SECTION 233346

SECTION 233400 - EXHAUST FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install exhaust fans as described in Contract Documents.

1.3 QUALITY ASSURANCES

- A. Requirements of Regulatory Agencies:
 - 1. Bear AMCA seal and UL label.

PART 2 - PRODUCTS

2.1 CEILING MOUNTED EXHAUST FANS

- A. Acoustically insulated housings.
- B. Sound level rating of 4.6 sones maximum for fan RPM and CFM listed on Drawings.
- C. Include chatterproof integral back-draft damper with no metal to metal contact.
- D. True centrifugal wheels.
- E. Entire fan, motor, and wheel assembly shall be easily removable without disturbing housing.
- F. Suitably ground motors and mount on rubber-in shear vibration isolators.
- G. Provide wall or roof cap, as required.
- H. Approved Manufacturers:
 - 1. Cook-Gemini
 - 2. Greenheck Sp
 - 3. Pace
 - 4. Penn Zephyr

2.2 ROOF MOUNTED EXHAUST FANS

- A. Direct drive or have adjustable pitch V-belt as noted on Drawings.
- B. Wheels shall be backward curved and housing shall be removable or hinged aluminum.
- C. Isolate motor with vibration dampeners.

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- D. Provide quiet type back-draft dampers.
 - E. Insulated, pre-fabricated metal roof curb shall be for flat or sloped roof as shown on Drawings.
 - F. Approved Manufacturers:
 - 1. Fans:
 - a. Penn
 - b. Centri-Master
 - c. Cook
 - d. Greenheck G, GB
 - 2. Standard curbs:
 - a. Penn
 - b. Cook
 - c. Greenheck
 - 3. Sound attenuating curbs:
 - a. Penn
 - b. Greenheck

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Anchor fan units securely to structure or curb.

END OF SECTION 233400

SECTION 233450 - HVAC FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 WORK INCLUDED

- A. The ceiling mounted, circulation fan shall be Big Ass Fans or approved equal. The fan shall be the model scheduled with the capacities indicated. The fan shall be furnished with standard mounting hardware and variable speed controls.

1.3 RELATED WORK

- A. Factory installation services shall be available through the manufacture; consult the appropriate installation scope of work for more information. Installation of the fan, miscellaneous or structural metal work (if required), field electrical wiring, cable, conduit, fuses and disconnect switches other than those not addressed in the installation scope of work consulted, will be provided by others.

PART 2 - PRODUCT

2.1 MANUFACTURER

- A. Delta T Corporation, dba Big Ass Fans, PO Box 11307, Lexington, Kentucky 40575. Phone (877) 244-3267. Fax (859) 233-0139. Website: www.bigassfans.com or approved equal.

2.2 HIGH VOLUME, LOW SPEED FANS

- A. Complete Unit:
 - 1. The fan shall be ETL certified and built pursuant to construction guidelines set forth by UL standard 507 and CSA standard 22.2. The fan shall be designed to move an effective amount of air for cooling and destratification in large industrial applications over an extended life. The fan and components shall be designed specifically for high volume, low speed fans to ensure lower noise operation. The sound levels from the fan operating at maximum speed shall not exceed 55 dBA (measured 20' or 6.1 m below the blades and 20' or 6.1 m horizontally from the center of the fan).
- B. Airfoils:
 - 1. The fan shall be equipped with ten (10) high volume, low speed airfoils of precision extruded aluminum alloy. Each airfoil shall be of the high performance Powerfoil design. The airfoils shall be connected by means of two (2) locking bolts per airfoil. The airfoils shall be connected to the hub and interlocked with zinc plated steel retainers.
- C. Winglets:

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1. The fan shall be equipped with ten (10) Powerfoil winglets designed to redirect outward airflow into downward airflow, thereby enhancing the efficiency and effectiveness of the fan. The winglets shall be molded of high density polypropylene and nominally measure 8-1/2" x 3" (21.6 cm x 7.6 cm). A winglet shall be attached at the tip of each airfoil by means of a barrel screw. The standard color of the winglets shall be "Safety Yellow."
- D. Motor:
1. The fan motor shall be an AC induction type inverter rated at 1725 RPM, 230/460 VAC, and 60 Hz for 3 ϕ and 1725 RPM, 208 VAC, and 60 Hz for 1 ϕ . The motor shall be totally enclosed, fan cooled (TEFC) with an IP55 NEMA classification. NEMA standard frames 56C/143TC/145TC shall be provided for ease of service. The motor shall be manufactured with a double baked Class F insulation and be capable of continuous operation in -30oF to 122oF (-34oC to 50oC) ambient conditions.
- E. Gearbox:
1. The fan gearbox shall be a NitroSeal™ Drive designed specifically for the Powerfoil X. The gearbox shall include a high efficiency, hermetically sealed, nitrogen filled, offset helical gear reducer with two stage
 2. gearing, a 2-1/2" (6.4 cm) hollow output shaft, cast iron housing, double lip seals, high quality SKF Explorer Series bearings with crowned cages for optimal lubrication flow, and precision machined gearing to maintain backlash less than 11 arc-minutes over the life of the unit. Lubrication shall be a high grade, low foaming synthetic oil with extreme pressure additives and a wide temperature range.
 3. The fan gearbox shall be equipped with a passageway in which wiring, piping, etc can be routed below the fan. A non-rotating, standard junction box shall be provided at the base of the fan for installing optional features such as lights, cameras, and VESDA. An aluminum cover plate shall be provided for attachment to the junction box when these features are not installed.
- F. Mounting Post:
1. The fan shall be equipped with a mounting post that provides a structural connection between the fan assembly and upper mounting system. The mounting post shall be 3" x 3" (7.6 cm x 7.6 cm) square tubing and powder coated for corrosion resistance and appearance. As an option, mounting post may be colored as specified by the architect or owner.
- G. Hub:
1. The fan hub shall be precision cast aluminum alloy for high strength and light weight. The hub shall be secured to the output shaft of the gearbox by means of a steel flange interface. Both hub and flange shall be precision machined to achieve a well balanced and solid rotating assembly. The hub shall incorporate five (5) safety retaining clips made of 1/4" (0.6 cm) thick steel that shall restrain the hub/airfoil assembly in case of gearbox output shaft failure.
- H. Mounting System:
1. The fan mounting system shall be designed for quick and secure installation from a structural support beam. All components in the mounting system shall be of welded

construction using low carbon steel no less than 3/16" (0.5 cm) thick and be powder coated for appearance and resistance to corrosion. All mounting bolts shall be SAE Grade 8 or equivalent. As an option, mounting components may be colored as specified by the architect or owner.

I. Safety Cable:

1. The fan shall be equipped with a safety cable that provides an additional means of securing the fan assembly to the building structure. The safety cable shall be 3/8" (1 cm) diameter and fabricated out of 7 x 19 stranded galvanized steel. The loops shall be secured with swaged Nicopress fittings, pre-loaded and tested to 3,000 lb·f (13,345 N).
2. Field construction of safety cables is not permitted.

J. Controller:

1. The fan controller shall be constructed using a Variable Speed Drive (VSD) that is pre-wired to the motor and factory programmed to minimize the starting and braking torques, for smooth and efficient operation. The controller shall be pre-wired to the motor using a short run of flexible conduit THHM with a dedicated ground conductor to minimize electromagnetic interference (EMI) and radio frequency interference (RFI). An incoming power cord shall also be pre-wired to the controller for ease of installation. The controller shall be contained within a completely sealed aluminum enclosure with an IP45 NEMA classification for 3 ϕ and a NEMA 4/12 rating for 1 ϕ . The controller will be secured to the mounting post 'onboard' the fan assembly.

K. Wall Control:

1. The fan shall be equipped with a remote wall control. The wall control shall be a digital keypad device mounted inside an aluminum bezel. The bezel shall be capable of mounting to a standard wall box. The wall control shall be equipped with touchpad controls and an LED display for controlling the fan's direction, operation and speed. Communication with the fan drive and controller shall be by a standard
2. commercially available CAT-5 (or higher) Ethernet cable that is field installed and provided by the installer. A 5' (1.5 m) 'patch cable' shall be provided to test and verify communication signals locally prior to connecting the remote connection cable.
3. The wall control shall be equipped with a simple diagnostic program to identify faults in the system. Provisions must be made for retrieving fan operation and diagnostic data (fault messages) through the remote wall device.

L. Warranty:

1. The manufacturer shall replace any products or components defective in material or workmanship, free of charge to the customer (including transportation charges within the USA, F.O.B. Lexington, KY), pursuant to the complete terms and conditions of the Big Ass Fans Non-Prorated Warranty in accordance to the following schedule:
 - a. Airfoils Lifetime (Parts)
 - b. Hub Lifetime (Parts)
 - c. Motor 10 years (Parts)†
 - d. Gearbox 10 years (Parts)†
 - e. Controller 10 years (Parts)†
 - f. Labor 1 year††

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- g. † 10 year parts warranty only valid with factory installation, 5 year parts without factory installation.
 - h. †† All reasonable costs of repair or replacement will be paid or reimbursed provided customer obtains pre-approval; see full warranty for details.
2. Further information on the terms and conditions of the warranties can be found in the Installation Guide.

PART 3 - ANCILLARY

3.1 INSTALLATION

- A. The fan shall be mounted to an angle iron or I-beam structure. Consult the Installation Guide for acceptable I-beam width, and proper sizing and placement of angle iron for a span mount. A structural engineer must be consulted for installation methods outside the manufacturer's recommendation and a certification submitted prior to installation.
- B. To reduce the risk of injury to persons, the fan shall be installed so that the airfoils are at least 10' (3 m) above the floor. The fan installation area must be free of obstructions such as lights, cables, sprinklers or other building structures; with the airfoils at least 2' (61 cm) clear of all obstructions. The fan should not be installed where it will be continuously subjected to wind gusts or in close proximity to the outputs of HVAC systems.
- C. If the fan is hung from an extension tube that measures 4' (1.2 m) or longer, it may be necessary to provide guy cables or struts to limit potential lateral movement of the fan. A stiffening strut braced against an additional beam may be required if there is a close clearance situation.
- D. The design criteria for the fan mounting system shall be capable of handling 300 ft·lbs (407 N·m) of torque.

3.2 WORKMANSHIP

- A. Good workmanship shall be evident in all aspects of construction. Field balancing of the airfoils shall not be acceptable.

3.3 DOCUMENTATION

- A. The manufacturer shall furnish a copy of all operating and maintenance instructions for the fan.
- B. All data is subject to change without notice. Data indicated in this document are for your convenience and were correct at the time of printing with the exception of clerical and/or printing errors. This document supersedes all previously published documents.

END OF SECTION 233450

SECTION 233713 - AIR OUTLETS & INLETS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install wall supply registers, transfer grilles, return air grilles, soffit grilles, ceiling diffusers, louvers connected to ductwork, and registers as described in Contract Documents.

PART 2 - PRODUCTS

2.1 GRILLES & REGISTERS

- A. Approved Manufacturers:
 - 1. Price
 - 2. Anemostat
 - 3. Krueger
 - 4. Titus
 - 5. Tuttle & Bailey

2.2 SPIN-IN FITTINGS

- A. Low pressure round take-offs to diffusers shall be made with spin-in fittings. They shall incorporate a manual balancing damper. The damper shall be spring loaded and a positive locking wing nut shall secure the damper position.
- B. Approved Manufacturers:
 - 1. Sheet metal fittings: Genflex DB-1DEL, Hercules

2.3 LOUVERS

- A. Extruded aluminum, with blades welded or screwed into frames and 1/2 inch mesh 16 gauge aluminum bird screen.
- B. Frames shall have mitered corners.
- C. Louvers shall be recessed, flanged, stationary, or removable as noted on Drawings.
- D. Approved Manufacturers:
 - 1. Airolite
 - 2. American Warming
 - 3. Arrow
 - 4. Industrial Louvers
 - 5. Ruskin

6. Vent Products

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Anchor securely into openings.
- B. Install with screws to match color and finish of grilles and registers.
- C. Touch-up any scratched finish surfaces.
- D. Install in accordance with manufacturer's instructions.
- E. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.
- F. Install diffusers to ductwork with air tight connection.
- G. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly.
- H. Paint ductwork visible behind air outlets and inlets matte black. Refer to Section 09 9000.

END OF SECTION 233713

SECTION 234100 – DISPOSABLE FILTERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install filters used in mechanical equipment.

PART 2 - PRODUCTS

2.1 FURNACE FILTERS

- A. Filters shall be one inch thick throw-away type as recommended by Furnace Manufacturer.

END OF SECTION 234100

SECTION 234145 – FURNACE AIR PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 23 0501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install furnace vent piping and combustion air intake piping as described in Contract Documents.

PART 2 - PRODUCTS

2.1 AIR PIPING

- A. Schedule 40 pipe and fittings meeting requirements of one of following:
 - 1. ASTM D 1785-89, "Specification for Poly(Vinyl Chloride)(PVC) Plastic Pipe, Schedules 40, 80, and 120."
 - 2. ASTM D 2661-89, " Specification for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Drain, Waste, and Vent Pipe and fittings."
 - 3. ASTM D 2665-89a, "Specification for Poly(Vinyl Chloride)(PVC) Plastic Drain, Waste, and Vent Pipe and Fittings."

2.2 PRIMER & CEMENT

- A. Meet requirements of ASTM D 2564-88, "Specification for Solvent Cements for Poly(Vinyl Chloride)(PVC) Plastic Pipe and Fittings."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Do not combine furnace drain piping with cooling coil drain piping.
- B. Run individual vent and individual combustion intake piping from each furnace to outdoors with location and formation recommended by Furnace Manufacturer. Slope lines downward toward furnaces.
- C. Slope combustion chamber drain downward to funnel drain. Anchor to wall with wall clamps, allowing free movement through clamp for expansion.
- D. Use vent terminal kit or clamping system provided by Furnace Manufacturer. Install vent and combustion air intake piping at clearance and distances required by Furnace Manufacturer.
- E. Attach factory-supplied neoprene coupling to furnace combustion-air inlet connection and secure with clamp.

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- F. Ensure that factory-supplied perforated metal disc is installed in flexible coupling, unless its removal is required.

END OF SECTION 234145

SECTION 235416 – SEPERATED COMBUSTION UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 230501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install separated combustion unit heaters as described in Contract Documents.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

- A. Provide high-efficiency, separated combustion, gas fired unit heaters as manufactured by Reznor. They are to be designed for a fuel use improvement of 25% and engineered for use in building areas with negative pressure and/or extremely dirty or mildly corrosive atmospheres. The use of a factory-installed power venter to draw combustion air from outside is to prevent dirt, lint, dust, or other contaminants present in the heated space from entering the unit. The combustion air supply pipe and flue exhaust pipe shall be run parallel to a factory-supplied (horizontal), (vertical) vent terminal assembly. The vent terminal assembly shall be arranged to provide preheating of the combustion supply air and to allow a single wall or roof penetration.
- B. The SC series shall be provided with a 24-volt control transformer, a(n) (single-stage), (two-stage), (electronic modulation) gas control system with a regulated combination redundant gas valve and an intermittent spark pilot with electronic flame supervision (and timed lockout). The SC is to include all limit and safety controls, including a combustion air pressure differential switch to verify proper vent flow before allowing operation of the gas valve.
- C. Each unit shall be equipped for use with (natural), (propane) gas and (120/1), (208/3), (203/3), (460/3) volt power supply. The heat exchanger shall be the Reznor Themrocore design of (aluminized), E-3 [408] stainless steel and include flared ports (burner air shutters) and a stainless steel insert. The units shall be designed for 80% thermal efficiency.
- D. These units are to be propeller fan(s), open drip-proof fan motor(s) with internal overloads, and safety fan guard(s). Horizontal (and vertical) louvers shall be provided for directing air flow. The unit must be arranged for ceiling suspension with threaded hanger connections (and provided with hanger kits). The cabinet shall be constructed of zinc grip steel and finished with baked-on enamel.
- E. All separated-combustion unit heaters must be design-certified by the American Gas Association and bear the A.G.A. label.

END OF SECTION 235416

SECTION 235417 – HIGH EFFICIENCY NATURAL GAS FURNACE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, and Section 230501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install gas fired condensing high efficiency furnace as described in Contract Documents.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

- A. Fabrication:
 - 1. Furnaces shall be factory assembled units certified by AGA complete with blower section, furnace section, condensing coil, steel casing, piped, and wired.
 - 2. Blower section shall consist of cabinet, blower, and motor.
 - 3. Cabinet shall be of 22 gauge minimum cold rolled steel and have finish coat of baked-on enamel.
 - 4. Blower shall be Class 1, full DIDW, statically and dynamically balanced.
 - 5. Filters shall be one inch thick pleated throw-away type as furnished by furnace manufacturer.
 - 6. Provide furnace with accessory side mounted filter box frame and factory available bottom closure.
 - 7. Automatic controls:
 - a. 100% cut-off safety pilot
 - b. Manual gas shut-off valve
 - c. Operating automatic gas valve
 - d. Solid state type fan and thermal limit controls
 - e. 24 volt transformer
 - f. Electronic ignition system
 - g. Pressure switch safety for induced draft fan
- B. Units:
 - 1. Blower shall be driven by motor with adjustable pitch V-belt drive or by a multi-speed direct driven motor.
 - 2. Furnace section shall be enclosed in 22 gauge minimum enameled steel casing lined with foil covered insulation.
 - 3. Heat exchanger shall be ceramic or glass coated, stainless steel, or 18 gauge aluminized steel with 20 year minimum limited warranty.
 - 4. Units shall be rated at 93% minimum AFUE (Annual Fuel Utilization Efficiency) calculated in accordance with DOE test procedures.

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- 5. 2" or 3" intake and exhaust lines to outside with factory furnished combination flue/intake assembly for roof or sidewall.
 - C. Provide with Web enabled 7 day programmable thermostat equal to Honeywell Prestige.
 - D. Approved Manufacturers:
 - 1. Lennox
 - 2. Carrier
 - 3. York
 - 4. Trane

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

- A. Quality Assurance: Furnace manufacturer's representative shall start up and check out furnace equipment as follows:
 - 1. Verify proper gas orifice sizing for altitude.
 - 2. Clock gas meter for rated input.
 - 3. Verify and set gas pressure at furnace.
 - 4. Check and measure temperature rise.
 - 5. Check safety controls for proper operation.

END OF SECTION 235417

SECTION 235418 – RADIANT HEATING SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and Section 230501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install radiant heating system as described in Contract Documents.

1.3 QUALITY ASSURANCE

- A. Total heating system supplied shall be design certified by the American Gas Association and this per American National Standard Z83.6 - 1987 "Vented Infrared Radiant Heater".

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

- A. Burners shall be designed for firing in tandem without adverse effects from combustion gases from upstream burners.
- B. Burners shall be supplied to fire at the design of burners supplied and the design of burners supplied shall provide for maintaining a constant proportion of fuel gas to filtered combustion air. These conditions are met for burners in which the pressure of both fuel gas and combustion air are both introduced at zero (atmospheric) pressure and flow of each is established by a vacuum of downstream side of flow metering orifices.
- C. To assure a high degree of fail-safe operation, the design shall preclude flow of gas if any or all of the following abnormal conditions occur in the non-firing mode:
 - 1. Main valve fails in open position.
 - 2. Vacuum pump motor fails to operate.
 - 3. Power fails.
- D. To further assure a high degree of safety, the system will be under negative pressure at all times during operation to preclude the possibility of the escape of combustion gases inside the building.
- E. All combustion chambers and heat exchanger pipes connected to a vacuum pump shall be pre-purged with air for a period of at least 20 seconds (10 air changes minimum) prior to initiation of firing sequence.
- F. All combustion chambers and heat exchanger pipes connected to a vacuum pump shall be post-purged with air for a period of at least 20 seconds (10 air changes minimum) after shutdown of the last burner firing into the vacuum pump.

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- G. All vacuum pump motors shall be provided with vacuum switches to prevent energization of gas valves until vacuum is proven.
 - H. Burner: Each burner shall consist of heavy-duty cast iron burner head, pre-wired gas controls with electric ignition and combustion air filter. Each burner and control assembly will be factory equipped with means to attach a safety chain to facilitate safe remove. Each burner will be supplied with a device which will prevent the removal of the burner control doors until the entire burner and control assembly is removed to a work area.
 - I. Reflectors: To maximize downward directive release of infrared energy and minimize upward convection losses, all reflectors shall be designed and equipped as follows:
 - 1. Reflectors shall be of "deep dish" design with both lower edges protruding past the bottom of the heat exchanger tube.
 - 2. The end of each reflector run is to be provided with an end cap.
 - 3. All heat exchanger elbows and tees shall be covered with a reflector joint piece that connects the reflectors with no spaces allowed for loss of radiant energy.
 - J. Vacuum Pump: The housing shall be heavy-duty cast iron. The impeller shall be cast aluminum alloy dynamically balanced and mounted for direct drive on the motor shaft. The vacuum pump shall be acoustically isolated from the system with a flexible connector with temperature rating of 350 deg. F. minimum. The motor in the vacuum pump shall be secured with rubber mounts for acoustical isolation. Vacuum pump motor shall be 230/115V, 60 Hz, 3450 RPM, reversible rotation, with at least 3/4 HP, TEFC capacitor start, ball bearing and thermally protected.
 - K. Heat Exchanger: Radiant pipe (between burners and 20 feet downstream of last burner) shall be of 4" O.D. steel pipe (i.e. tubing). The balance of pipe shall be 4" O.D. steel tubing with an internal coating of acid-resistant porcelain. All heat exchanger (pipe) connections shall be made with stainless steel coupling assemblies. These will be of two types as follows: Unlined coupling for use with uncoated tubing or joints to connect uncoated tubing to coated tubing. The maximum input firing rate shall not exceed 2,400 BTU per hour per square foot of exterior radiating surface of heat exchanger for the heating system in total. The total heat exchanger surface is that associated with one vacuum pump.
 - L. Burner Control Modules: All burners shall be pre-wired with a three conductor electrical cord and plug with the third wire for ground circuit.
 - M. Panelbox for System Controls: Pre-wired system control circuits shall be supplied in a panelbox with each vacuum pump. The panelbox for the standard burners shall provide relays and terminals to accommodate up to four temperature zones with a thermostat and associated control circuits for the burners for each temperature zone. Provide complete with one thermostat.
 - N. Provide with 7-day programmable thermostat as recommended by Manufacturer. Provide water-proof thermostats in carwash bays and other wet locations.
 - O. Approved Manufacturers:
 - 1. CO-RAY-VAC
 - 2. Superior Radiant

-
3. Space Ray
 4. Reverber-Ray
 5. or approved equal

END OF SECTION 235418

SECTION 236213 - AIR-COOLED CONDENSING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, General Provisions of Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, and Section 230501 apply to this Section.

1.2 SUMMARY

- A. Furnish and install condensing units as described in Contract Documents.

1.3 WARRANTY

- A. Five-year warranty on compressors.
 - 1. Warranty time frame shall be five years from date of "start-up". "Start-up" date shall be recorded on warranty certificate for each unit.

PART 2 - PRODUCTS

2.1 TWO TON THROUGH FIVE TON UNITS

- A. Condenser coil shall have aluminum plate fins mechanically bonded to seamless copper tubes.
 - 1. Provide coil guard for unit.
- B. Fans shall be direct driven propeller upflow type.
 - 1. Fan motor shall be single or two speed, thermostatically controlled, permanently lubricated, and designed with permanent protection and ball bearings.
 - 2. Motors shall be resiliently mounted.
 - 3. Each fan shall have a safety guard.
- C. Units shall be operable down to 0 deg F outdoor temperature.
- D. Compressor shall be of hermetic design with the following features. Each condenser unit shall have only one compressor.
 - 1. Externally mounted brass service valves with charging connections.
 - 2. Crankcase heater.
 - 3. Resilient rubber mounts.
 - 4. Compressor motor overload protection.
 - 5. Single speed
- E. Controls:
 - 1. Factory wired and located in separate enclosure.
 - 2. Safety devices shall consist of high and low pressure cutout and condenser fan motor overload devices.
 - 3. Unit shall have anti-cycle timers to prevent units from starting up again for five minutes after any power interruption.

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- F. Casing:
1. Fully weatherproof for outdoor installation. Finish shall be weather resistant.
 2. Openings shall be provided for power and refrigerant connections.
 3. Panels shall be removable for servicing.
- G. Expansion Valves:
1. Stainless steel diaphragm and same refrigerant in thermostatic elements as in system. Externally or internally equalized as required by evaporator/condensing system.
 2. Size valves to provide full rated capacity of cooling coil served.
 3. Furnished by evaporator coil/condensing unit supplier and coordinated to provide bleed holes for system pressure equalization, if required.
- H. Condensing units shall use R-410A refrigerant. Only one liquid line, one suction line, and one power connection shall be made to each compressor. Provide charging valves.
- I. SEER rating as defined by ARI shall be not less than 13.0.
- J. Set each unit on neoprene isolation pads located at each corner and sized 4" x 4" x 3/4" high minimum.
- K. Approved Manufacturers:
1. York
 2. Carrier
 3. Lennox
 4. Trane

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Set condensing units as detailed on the drawings.

3.2 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service:
- B. Condensing units shall be started up, checked out, and adjusted by Condensing Unit Manufacturer's authorized factory trained service mechanic.
- C. Mechanic shall use check-out sheet provided by Manufacturer, complete and sign all items on sheet, and submit to Architect.

END OF SECTION 236213

END OF DIVISION 23