

PROJECT MANUAL
FOR
SECOND FLOOR HVAC IMPROVEMENTS
AT
SCHMIDT HALL
FOR



MARCH 2017



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Security

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PROJECT MANUAL
FOR
SECOND FLOOR HVAC IMPROVEMENTS
AT
SCHMIDT HALL
FOR
XAVIER UNIVERSITY

PREPARED BY

MOTZ ENGINEERING
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SECTION 230000 – HEATING, VENTILATING, AND AIR CONDITIONING WORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes a summary of all Heating, Ventilating, and Air Conditioning related work.
- B. Related Sections:
 - 1. 230000 – Heating, Ventilating, and Air Conditioning Work
 - 2. 230400 – General Heating, Ventilating, and Air Conditioning (HVAC) Requirements
 - 3. 230500 – Common Work Results for HVAC
 - 4. 230513 – Common Motor Requirements for HVAC Systems
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 - 31. 237314 – Variable Frequency Motor Controllers
 - 32. 238216 – Refrigerant Air Coils
 - 33. 238219 – Fan Coil Units

1.3 DESCRIPTION

- A. The General Conditions, Special Conditions and Division 1 through Division 32, as set forth in these specifications, are hereby incorporated into and shall become a part of the specifications for work under this title, insofar as they apply hereto.
- B. Furnish material, labor, tools, accessories and equipment to complete and leave ready for operation all HVAC systems for this project as described in these specifications and as shown on the drawings, or as required.

1.4 SCOPE OF WORK

- A. Work includes, but is not limited to:
 - 1. Furnish and install new water pumps including all new valves and accessories.
 - 2. Furnish and install new equipment pads for all new equipment.
 - 3. Install chilled water, hot water and dual temperature water piping as indicated.
 - 4. Provide requisite drain and flushing connections for testing and chemical treatment.
 - 5. Furnish and install fan coil units.
 - 6. Furnish and install air cooled condensing unit.
 - 7. Furnish and install variable speed drives for pumps and fans.
 - 8. Clean existing ductwork.
 - 9. Furnish and install all required condensate, equipment and drain piping.
 - 10. Furnish and install pipe, equipment and duct insulation.
 - 11. Furnish and install new instruments as shown.
 - 12. Furnish and install fans as indicated on the drawings.
 - 13. Furnish and install new ductwork and all associated grilles, diffusers, registers, etc.
 - 14. Perform air and water balancing.
 - 15. Perform final setting and leveling of all new equipment.
 - 16. Perform start-up for all HVAC systems and commission same in accordance with the commissioning requirement.
 - 17. Provide and/or participate in training of Owner's personnel on the use of all new HVAC systems.
 - 18. Furnish and install requisite drain and finishing connections for testing and chemical treatment.
 - 19. Refer to drawings for Schedules of HVAC Equipment.
 - 20. The contractor shall exercise adequate protective and safety measures for all persons and property and shall be responsible for any damages or injuries arising from the execution of this work.
 - 21. Alterations and additions to existing work shall include the requisite dismantling of the old equipment, rigging, wrecking, hauling, protections of permanent equipment and the building structures, and cleaning up. Care shall be exercised to keep dust and dirt to a minimum and to confine it to the area where the removal work is being performed. All debris shall be promptly removed.
 - 22. If asbestos insulation is encountered on any existing piping which is to be removed or remodeled, contractor shall immediately notify Owner of the existence of asbestos and Owner will arrange proper removal of same without cost to contractor.

23. Unless otherwise noted, remove all other existing equipment and piping, valves, fittings, etc. which will not be reused in the final arrangement. Unless otherwise noted, all items which will be removed by this this contractor and not reused shall become the property of the contractor and shall be promptly removed from the site by him.
24. The existing facility will be partially occupied and will remain in operation throughout the period that this work is being performed, and certain new work will be performed during this period. Unscheduled interruptions of the facility will not be tolerated. The contractor shall exercise extreme caution, shall thoroughly inform his workmen and subcontractors of the critical nature of this work, and shall continually review the work procedure being followed in order to prevent accidental interruption of service. Before performing any act which could result in interruption of service, the contractor shall notify the Owner and Engineer of the hazards involved and the contractor shall proceed in a manner and at a time specifically approved by the Owner and Engineer.
25. All work necessitating the temporary turning off or shutting down the operation of existing mechanical and/or electrical facilities shall be done at times specifically approved by the Owner and Engineer in advance of any disruption of existing facilities. Also, refer to Section 23 04 00 – General Heating, Ventilating, and Air Conditioning (HVAC) Requirements.

B. Demolition Work

1. Coordinate all Demolition with the Owner so that shutdowns occur at times agreeable to the Owner.
2. The HVAC Contractor shall remove certain existing air handling systems. The existing plans are available for review at the Engineer's Office and the Owner will provide access to contractors desiring to verify existing conditions. The contractor shall be responsible to verify the extent of demolition work and shall include in their bid all demolition work affecting their trade.

1.5 EXCAVATION AND BACKFILLING AND RESTORATION OF SURFACES

- A. Refer to Division 1 and Section 23 04 00.

1.6 EQUIPMENT

- A. Any and all costs associated with piping, electric, wiring, conduit, supports, pads, or other modifications to accommodate installation for manufacturer's equipment that differs from equipment layout on drawings shall be included on contractor's bid. The contractor is responsible to insure that the equipment will fit within space allocated with appropriate clearances for maintenance, operation, servicing, and code.

1.7 DUKE ENERGY INCENTIVE PROGRAM

- A. Comply with all requirements of the Duke Energy Incentive Program in order that the Owner will be able to obtain incentive monies from Duke Energy for this project. If Duke Energy requirements are more restrictive than the specifications, the Duke Energy requirements shall govern. A copy of the Duke Energy Incentive information

for equipment is available on their web site. The contractor shall complete these forms, provide all requisite documentation, and present this information to the Owner for submission to Duke Energy. The incentive monies shall be solely available to the Owner.

1.8 QUALIFICATIONS

- A. Installer: Company specializing in performing the work of this Section with minimum three years documented experience.

1.9 LICENSES

- A. The installation of this HVAC work shall be made by Contractors and craftsmen licensed by the Governing Authorities.
- B. Obtain all permits and licenses required by code authorities having jurisdiction.

1.10 FEES

- A. The Contractor shall obtain all inspections or permits required by all laws, ordinances, rules, regulations or public authority having jurisdiction and obtain certificates of such inspections and permits and submit same to the Architect. The Contractor shall pay all fees, charges and other expenses in connection therein for HVAC work including inspection fees, etc. associated with the building permit.

1.11 CODES, REGULATIONS AND STANDARDS

- A. Unless otherwise noted, the following latest enforced Edition shall apply to this work:

- Ohio Building Code
- Life Safety Code
- National Fire Protection Association
- Ohio Fire Code
- OSHA Requirements
- EPA Requirements

1.12 QUALITY ASSURANCE

- A. The HVAC Contractor shall be responsible for all costs associated with changes to wire size, conduit size, fuse size, starter size, pipe size, duct size, monitoring, supports, etc. caused by the change of equipment from the basis of design specified to other named manufacturers. The Contractor is responsible to insure that the other manufacturer named supplied equipment will fit within space allocated, with appropriate clearances for maintenance, operation, service, code requirements, etc. Any contractor utilizing a manufacturer other than basis of design shall be responsible for any additional requirements for electrical service, concrete pad size, physical space limitations, and capacities at no additional cost to the building Owner. If manufacturers are listed, no other manufactures except those listed within the Sections of this Division, that are able to comply with the contract document requirements and minimum standards of these specifications, will be acceptable.

- B. Work provided or performed by the Contractor shall be guaranteed to be replaced and made good at his own expense any defects which may develop, within one (1) year after final payment and acceptance by the building Owner, due to faulty workmanship or material, upon receipt of written notification of the defect from the building Owner.

PART 2 - NOT APPLICABLE

PART 3 – EXECUTION

3.1 EXISTING WORK

- A. Each Contractor shall locate existing site utilities, installed in previous phase, prior to beginning work. Provide adequate means of protection during work operations. Repair existing utilities damaged during work operations to the satisfaction of the utility owner and at Contractor's expense.
- B. Should uncharted or incorrectly charted piping or other utilities be encountered during work operations, notify the Engineer immediately for procedure directions. Cooperate with utility companies in maintaining active services and facilities in operation.

3.2 OPENING LOCATIONS AND CUTTING

- A. Each Contractor shall be responsible for their required openings.
- B. All cutting through poured concrete slabs and walls shall be done with core drills. No jack hammers will be allowed. All cutting and patching shall be by this Contractor.

3.3 CLEANING AND PAINTING

- A. All equipment shall be kept dry and clean during the construction period.
- B. Prime and paint by this Contractor.
- C. When all work is completed and all work has been satisfactorily tested and accepted by the Architect, mechanical equipment and other exposed surfaces shall be thoroughly cleaned.
- D. Repair marred and damaged factory painted finish with materials and procedures to match original factory finish.

3.4 CONCRETE WORK

- A. Each Contractor shall provide concrete pads required for equipment they have supplied. See Division 3 - Cast-in-Place Concrete.

3.5 PROTECTION AND DAMAGE

- A. In addition to the provisions and stipulation of the General Conditions, each contractor and subcontractor shall provide various types of protection as follows:
1. Protect finished floors from chips and cutting oil by the use of metal drip receiving pan and oil proof floor cover.
 2. Protect equipment and finished surfaces from welding and cutting splatters with baffles and splatter blankets.
 3. Protect equipment and finished surfaces from paint droppings, insulation adhesive and sizing droppings, etc. by use of drop cloths.
- B. All equipment shall be stored at the site with openings, bearings, etc., covered to exclude dust and moisture. All stock piled pipe shall be placed on dunnage and protected from weather and from entry of foreign material.
- C. Piping and construction openings and excavations required for Mechanical work shall be covered when work is not in progress as follows:
1. Cap pipe openings with fittings or plugs.
 2. Cover wall and ceiling openings with plywood, or canvas covered framing.
 3. Cover floor openings and excavations with structural material of adequate strength to support traffic.
- D. The Owner's property and the property of other Contractors shall be scrupulously respected at all times (including damage from leaks). Provide drop cloths and visqueen or similar barriers where dust and debris is generated, to protect adjacent area.
- E. Contractor shall be held responsible for damage caused by his work or through neglect of his workmen. Repairing of damaged work shall be done by Contractor as directed by the Architect. Cost of repairs shall be paid by Contractor.
- F. The Owner reserves the right to make emergency repairs as required to keep equipment in operation without voiding the Contractor's guarantee bond not relieving the contractor of his responsibilities during the bonding period.

END OF SECTION 230000

SECTION 230400 - GENERAL HEATING, VENTILATING, AND AIR CONDITIONING (HVAC) REQUIREMENTS

PART 1 - GENERAL

1.1 HVAC WORK

- A. The following paragraphs are applicable to Division 23 and are complementary to other sections of specifications. Where items described in other sections of the specifications are repeated herein, it is done to call special attention to or to qualify them, but it is not intended that any part of the documents shall be assumed to be omitted if not repeated herein.
- B. Where contradictions occur between this section and Division 1, the more stringent of the two shall apply. Architect/Engineer shall decide which is most stringent.

1.2 DRAWINGS AND SPECIFICATIONS

- A. HVAC drawings are diagrammatic and indicate general arrangement of systems and work included in the contract and shall be adhered to insofar as possible. The drawings and specifications are complementary and are intended, without giving every minute detail, to cover a workable installation complete in every respect including, whether mentioned or not, all material and equipment usually furnished with such systems and/or needed to make a complete operational installation omitting only such parts as are specifically excepted.
- B. Consult drawings and details for exact location of fixtures and equipment, and where not definitely indicated, request this information in writing.
- C. The specification for each division of the work is written in sectional form for brevity and convenience in reference, without repeating in each section all applicable general clauses and/or pertinent data covered elsewhere in the specification, but it is not intended that any of the documents shall be assumed to be omitted if not repeated in each division.
- D. Where specifications are written for brevity, with incomplete sentences, the omission of words or phrases, such as "the contractor shall", "shall be", "provide", "furnish", "all", etc. are intentional and such omitted words or phrases shall be supplied by inference; unless otherwise mentioned, such clauses, lists, and/or directives indicate work to be done by the contractor for that specific division of work.

1.3 VERIFYING CONDITIONS

- A. The work under this contract occurs on the site of and within the existing facility. The work under this contract shall be scheduled and performed so as to provide a minimum of interference with the normal operation of the existing facilities.
- B. Before submitting a proposal, contractors shall visit the site, and shall also carefully examine all bidding documents including those for other branches of the work, to satisfy themselves as to the nature and scope of all work to be done. Prints showing the original building architectural, structural, mechanical, and electrical

work are available at the Engineer's office for contractors' review.

- C. The submission of a proposal shall be taken as evidence that such an examination has been made and difficulties, if any, noted. Later claims for labor, work, material, and equipment required for any difficulties encountered which could have been foreseen, shall not be recognized, and all such difficulties shall be properly taken care of by the contractor at no additional expense to the Owner.

1.4 EXISTING WORK AND/OR CONDITIONS

- A. The accompanying drawings and specifications illustrate and describe the existing conditions, mechanical utilities, sewers, water mains, pipes, ducts, conduits, etc. that are particularly relevant to the new work insofar as these mains are shown on existing records or evident by field inspections and tests; however, it is not the intent that these documents shall be construed to guarantee to the contractor the exact location of these items. Each contractor shall verify and determine the exact location of these items in the field, and all work under this contract shall be executed to avoid conflict with or damage to existing work. The work shall be planned and executed to avoid interference, as much as possible, with traffic and with the normal use of the existing facility.
- B. All work involving hazards to persons shall be suitably barricaded and provided with warning lights or signs, as required.
- C. Where necessary for the performance of the contract, existing work shall be cut, altered, removed, or temporarily removed and replaced. Work that is altered or replaced shall match similar existing work and said work shall be performed by trade applicable to the work; if said work is NOT shown or noted the Drawings relating to applicable trade, cost shall be paid by contractor requiring said work. However, unless otherwise provided by the drawings or specifications, no structural members shall be cut or altered without authorization of the Architect and Engineer. Work remaining in place, which is damaged or defaced by reason of work done under this contract, shall be restored in kind equal to its condition at the time of award of the contract by applicable trade as hereinbefore specified.
- D. Existing work shall not be disturbed further than necessary for proper installation of new work. New work to be connected or made integral with existing work shall be properly erected to secure solidity and be continuous in finish. Such new work in extension of existing work shall correspond in all respects with that to which it connects, or similar existing sound work, unless otherwise specified.

1.5 EXISTING MECHANICAL FACILITIES

- A. Where existing mechanical facilities and/or service lines occur in the area of the work and such facilities or lines are to be abandoned or changed, the contractor for the branch of work or trade involved shall cut off and properly cap the old lines, so as not to interfere with the new construction work. If any portions of such lines are required for the operation of an existing building the lines shall be altered and relocated to clear new construction and shall also be restored into service to provide continued operation of the existing building.

1.6 INTERRUPTION OF SERVICES

- A. Work which requires the temporary turning off or shutting down the operation of existing mechanical and/or electrical facilities shall be done at times specifically approved by the Owner or utility company and the work shall be pre-scheduled and executed so there is a minimum outage of such services and/or delay in the new construction work.
- B. Unscheduled interruptions of the facility will not be tolerated. The contractor shall exercise extreme caution, shall thoroughly inform his workmen and subcontractors of the critical nature of this work, and shall continually review the work procedure being followed in order to prevent accidental interruption of service. Before performing any act which could result in interruption of service, the contractor shall notify the Owner and Engineer of the hazards involved and the contractor shall proceed in a manner and at a time specifically approved by the Owner and Engineer.
- C. All work necessitating the temporary turning off or shutting down the operation of existing mechanical and/or electrical facilities shall be done at times specifically approved by the Owner and Engineer in advance of any disruption of existing facilities.

1.7 MATERIALS AND EQUIPMENT

- A. All materials and equipment entering into the work shall be approved by the Engineer, and must be new, without defects, and of the sizes and capacities shown on the drawings or hereinafter specified. All manufactured materials or equipment shall bear the identification mark of the manufacturer or, if required by the Engineer, shall be certified by an approved testing laboratory. All equipment shall operate within the manufacturer's range of speeds, guaranteed capacities, performance, etc. as indicated by the manufacturer's latest catalog and/or engineering data, shall be of proper size and dimension for the allocated space, and shall be placed in the space allocated in the proper construction sequence. Special consideration will be given to equipment which has been in successful field use or similar applications for at least three (3) years (exclusive of field tests), and to equipment which has an extended guarantee period in lieu of long use period. The contractor shall submit with his bid complete data on equipment he proposes to use; failure to so submit, or to meet these requirements fully and those of the specifications, shall be grounds for rejecting the items.
- B. All electrical materials, apparatus, and equipment shall be new, of the make and characteristics specified, shall conform to NEMA standards, and shall be designed to comply with and be installed in accordance with the latest rules and regulations of the National Electrical Code, and all of the legally constituted public authorities having local jurisdiction. Verify the exact voltage and current characteristics at the building before ordering motors or similar equipment.
- C. All motors shall be NEMA frame sizes, heavy duty, 40 degree C. ambient motors with ball or roller bearings and with maximum full load temperature rise not exceeding NEMA limits of temperature rise. All motors shall have adequate starting and protective equipment as specified or required, and shall have a conduit terminal box of size adequate to accommodate conduits and wires as sized on electrical

drawings or as specified. The capacity of each motor shall be sufficient to operate associated driven devices under all conditions of operation and load without overloading or overheating and each motor shall be of not less than the horsepower indicated or specified.

- D. Conduct such tests and adjustment of equipment as specified or necessary to verify performance requirements. Submit data taken during such tests.

1.8 QUIET OPERATION

- A. The work shall be installed in such a manner that under all conditions of load it shall operate without sound or vibration which is objectionable in the occupied spaces, in the opinion of the Engineer.
- B. In case of moving machinery, sound or vibration noticeable outside of the room in which it is installed or annoyingly noticeable inside its own room will be considered objectionable. Sound or vibration considered objectionable shall be corrected by the contractor.

1.9 PROTECTION

- A. In performing this contract, safeguard workmen and the public and protect the work and equipment until final completion and acceptance. After delivery and before and after installation, protect work against theft, injury, or damage. Carefully store material and equipment received on site which are not immediately installed. Close open ends of work with temporary covers or plugs during construction to prevent entry of obstructing materials. Protect related or adjacent work and the material of the other trades or the Owner from damage that might be caused by this work and make good any damage thus caused. Provide all safeguards, scaffolding, drop cloths, etc. as required.
- B. No welding or soldering shall be done near combustible materials of any kind; all adjoining work, finished surfaces, glass, etc. shall be protected from flames, sparks, hot metal, etc. by metal guards or approved noncombustible drop cloths or barriers.
- C. Each contractor shall replace any items or portions thereof wherever removed or damaged, in a manner equal to the original construction and finish, or where directed by the Engineer, he shall pay other trades to perform this work.
- D. All mechanical equipment with a factory finish shall be protected during construction and must be free of dust, dirt, cement splatters, etc. when the building is turned over to the Owner. Dents and marred finishes shall be repaired to the satisfaction of the Engineer, or a replacement furnished where necessary.
- E. Provide belt drives and rotating machinery with readily removable guards complying with OSHA requirements to enclose the drive completely and consisting of heavy angle iron frames, hinged and latched, with heavy galvanized iron wire crimped mesh or sheet steel securely fastened to frames.

1.10 EXECUTION OF WORK

- A. The HVAC Work shall be performed and coordinated with the program of the General Contractor and the other subcontractors. Promptly upon award of the contracts, the subcontractors shall confer with the General Contractor and the Engineer and other subcontractors to prepare a time schedule for the completion of the various divisions and details of the work. Each subcontractor shall proceed diligently with the work and shall cooperate with the General Contractor and the other contractors to maintain the approved time schedule to the best of his ability and as conditions permit.

1.11 GENERAL SUPERVISION AND INSTALLATION OF WORK

- A. Each contractor shall at all times give the work his best skill and attention, including adequate construction supervision over his work, employees, and subcontractors, and he shall fully cooperate with and confer with the Engineer and other contractors so that the best possible installation shall be obtained. Exact locations and relations are to be determined in the field, subject to the approval of the Engineer, and with preference to the dimensioned and architectural and structural drawings and approved shop and setting drawings.
- B. Unless otherwise shown, pipes, ducts, etc. in rooms with finished ceilings, shall be concealed in furred ceilings, shafts, walls, and floors, and all work must be exactly and accurately located to conform with the spaces provided therefor. In general, all other new piping, ducts, etc. in mechanical equipment rooms, telephone rooms, etc. shall be exposed.
- C. Install pipes, ducts, etc. in a neat and workmanlike manner, close to walls, generally as high as possible, true and square to the building, utilizing standard practices, and properly graded for correct functioning of the system involved; multiple lines in close proximity shall be coordinated and neatly grouped. Install work in proper construction sequence and arranged so as to be readily accessible for operation, maintenance, and repair; minor deviations from drawings may be made to accomplish this, but changes of magnitude or which involve extra cost shall not be made without approval. All fixtures, outlets, etc. shall truly center with the adjacent architectural finish. All work, both exposed and concealed, shall meet the approval of the Engineer regarding neatness of appearance, location, and practicability of installation. The Engineer reserves the right to direct the removal and replacement of any item which, in his opinion, does not present an orderly and reasonably neat and workmanlike appearance.
- D. Each contractor shall familiarize himself with the work of the other contractors, shall perform and coordinate his work with the other contractors, shall lay out his work to meet conditions at the building, shall give freedom to and prevent conflict with the work of other contractors, and shall make reasonable modification in locations or arrangement from those indicated on the drawings if required to avoid conflicts or to conform to tile, wood, marble, or other architectural finish. From time to time as the work progresses, the contractor shall examine the work installed by others, insofar as it may affect his work, and he shall, before proceeding with the work, notify the Engineer in writing, if any condition exists which prevents the successful installation of his own work.

- E. If the contractor places any work in violation of any of the above mentioned requirements, and conflicting or unworkmanlike conditions result, he shall, without additional charge, remove and reinstall or satisfactorily readjust such portions of his work as may be necessary and as the Engineer may direct. The Engineer's decision regarding such conditions shall be final.

1.12 ENGINEER'S OBSERVATION

- A. A periodic inspection of the work by the Engineer, commonly referred to as supervision, is only for the express purpose of verifying compliance by the contractor with the contract documents. Such engineering inspections and services rendered by the Engineer or his representatives shall not be construed as the supervising of construction; nor the assuming by the Engineer of the duties and responsibility of the contractors nor making the Engineer responsible for providing a safe place or procedure for the performance of the work or for the contractor's employees or for subcontractors.

1.13 EXCAVATION AND BACKFILLING OF TRENCHES, ETC.

- A. Unless otherwise specified, the HVAC Contractor shall do all excavation of trenches for piping, etc. in connection with his work, and after his work is in place and inspected by the Engineer and Civil Authorities, he shall backfill in layers of not to exceed six inches (6") in depth, thoroughly moistened, thoroughly rammed, tamped, and compacted to a density at least equal to the surrounding earth to minimize after settlement. If, in the opinion of the Engineer, the excavated material is unsuitable for backfilling, the contractor shall backfill with bank run gravel well compacted. The bottom of each sewer trench shall be filled with sand to an elevation of 6" above the top of the sewer. Top of backfill or trench surface shall be level with adjoining ground or surface; furnish additional material if required to fill trenches. All surplus earth shall be moved by this contractor and disposed of as directed by the Engineer. Compact backfill in trenches within building lines the same as specified in architectural branches.
- B. Any sheet piling or shoring or pumping necessary shall be done by this contractor at his own expense and all trenches shall be dug in a careful manner, with bottoms properly pitched to insure perfect drainage and to provide uniform bearing and support for each section of pipe on undisturbed soil along its entire length, except where it is necessary to excavate for bell holes and for the proper sealing of pipe joints. The bottoms of all sewer trenches shall be excavated 6" below the bottom elevation of the sewer and backfilled with sand so at least one-third of the circumference of the pipe will rest firmly on tamped sand. These trenches shall be not less than 12" wider, nor more than 16" wider, than the outside diameter of the pipe to be laid therein; this requirement applies to the width at and below the level of the top of the pipe; the width above that level may be wider for proper sheeting and bracing and the proper installation of the work. Shoring, bracing, barricades, etc. shall be provided to protect the workmen and/or public amply; refer to the Ohio Bulletin No. 201 "Specific Safety Requirements Relating to Building and Construction Work".
- C. Unless otherwise approved, the following minimum cover shall be provided above the top of underground pipes outside the buildings: Water lines, refer to elevations

on plans.

- D. Whenever wet or otherwise unstable soil, that is incapable of properly supporting the pipe as determined by the Engineer, is encountered in the trench bottom, such soil shall be removed to a depth required and for the length designated by the Engineer, and the trench backfilled to trench bottom grade with coarse sand, fine gravel, or other suitable materials, properly compacted.
- E. Excavation near or under building footings shall be backfilled with concrete installed under the direction of the Engineer.
- F. Where contractor elects to have any excavation work performed by a subcontractor, subcontractor must be approved by the Owner prior to commencing any work.
- G. Construction Fence
 - 1. Refer to Division 01.

1.14 RESTORATION OF SURFACES AND CONCRETE WORK

- A. Unless otherwise specified, all new concrete work for parking lots, driveways, pads, etc. shall be provided by this contractor. Unless otherwise specified, all new concrete work for pads, and all surfaces such as concrete floors, walls, paving, sidewalks, roof deck, or other surfaces disturbed in the execution of work, and which remain in use, shall be restored in kind by this contractor, or he shall pay the cost of such work.
- B. Where this contractor has performed excavation work, this contractor shall backfill as hereinbefore specified in Paragraph 1.16.
- E. Concrete Work, shall be performed by a qualified, competent, Concrete Contractor, and work shall comply with the following:
 - 1. Sidewalks shall be concrete, Class C, unreinforced, complying with ODOT 608. Width and finish shall match existing adjacent sidewalks. Sidewalks shall be the same depth as the existing adjacent sidewalks or 7" deep whichever is greater.
 - 2. All other concrete for parking lots, driveways, and pads shall be 4000 PSI compressive strength concrete with reinforcing steel. Thickness of concrete for parking lots and driveways shall be not less than 7" thick. Reinforcing steel shall be 6" x 6" 58 pound welded wire fabric (WWF) top and bottom. All welded wire fabric shall be in flat sheets, not rolls.

1.15 SLEEVES, CUTTING, PATCHING, CLEANING, WATERPROOFING, ETC.

- A. Provide and accurately set frames and Schedule 40 steel pipe sleeves for required openings in new work to minimize cutting. Perform all cutting, patching, etc. required to install the work. Use approved power operated boring machine for small holes wherever practical. Remove all rubbish incidental to the work. Where any work pierces waterproofing, provide all necessary sleeves, caulking, and

flashing required to make openings absolutely watertight.

- B. Refer to the ACI Code 381.71, Section 6.3 for limitations and requirements for penetrations and openings.

1.16 PATENTS

- A. The contractor shall defend and guarantee the Owner against any expense, claims, litigation, etc. occasioned by the use in this work of any materials, devices, etc. covered by patents not owned by the contractor, or of which he is not a licensed user.

1.17 CONTEMPLATED WORK

- A. The work contemplated occurs on the site of and within the existing building.
- B. The drawings and specifications for the mechanical and electrical portion of this project have been prepared by Motz Consulting Engineers, Inc., doing business as Motz Engineering.
- C. The various items of work necessary for completion of this work are hereinafter specified under the respective section headings or shown on accompanying drawings, and shall be included in any contract or contracts made for completion of respective divisions of the work. Such contracts shall also include necessary details reasonably incidental to the proper execution and completion of such work.

1.18 MOVING MATERIALS

- A. If it becomes necessary at any time during the progress of this work to move materials which have been temporarily located and which are to enter into the final construction, the contractor furnishing said materials shall, when so directed by the Engineer, move them or cause them to be moved. Cost of such moving shall be included in the contract price.

1.19 ACCIDENT PREVENTION

- A. Precaution shall be exercised at all times for the protection of persons and property. The safety provisions of applicable law, building, and construction codes shall be observed. Machinery, equipment, and other hazards shall be guarded in accordance with safety provisions of the "Manual of Accident Prevention in Construction" published by Associated General Contractors of America to the extent that such provisions are not inconsistent with applicable law or regulations.

1.20 PROPERTY PROTECTION

- A. All hoisting shall be done with proper tag lines and buffers to prevent damage to the sides of the building. Where it is necessary to hoist materials to the roof, the parapets at top of the building and the roof where materials are landed from hoists shall be protected with heavy wood covers. Parapet protection shall be placed on both sides and top, and shall extend far enough on either side of landing point to insure adequate cover. The roof, from the landing point at parapet to final location

of material, shall be adequately protected by planks laid side by side on roofing and spiked together on outside edges with planks running at right angles to main planking. The roof shall be adequately protected against leaks at all times.

- B. Where hoists are erected on the roof for hoisting material up the side of the building, the roof shall be adequately protected against abrasion or other damage. Materials stored on the roof shall be placed on planks or other protection approved by the Engineer and shall be placed only at locations approved by the Engineer.
- C. If hoisted materials are taken through windows, the jams, head, and sill shall be adequately protected with wood planking or proper buffers.
- D. Any work, equipment, or property damaged during construction of this project and due to operations under this contract shall be repaired or replaced by this contractor, without additional cost to the Owner. Upon completion of the work, the contractor shall remove all protections herein specified.

1.21 REMOVAL OF RUBBISH

- A. It shall be each contractor's duty to keep the building and surrounding premises clean, free from rubbish of every description. No rubbish, crating materials, packing, or dirt shall be allowed to accumulate at any time, but shall be removed at once and hauled away.
- B. Each trade shall be responsible for its own tools and materials during the periods of rubbish removal but contractors shall use reasonable care in removal of rubbish to protect the tools and materials of others against loss or damage. The Owner reserves the right, in the event that removal of rubbish is not promptly and properly carried out by the Contractors to have rubbish removed and to charge the cost of its removal to the contractor.
- C. Also, refer to Division 1.

1.22 MATERIAL SAFETY DATA SHEETS (MSDS)

- A. The contractor shall obtain and maintain on-site during the course of the project the Material Safety Data Sheets (MSDS's) for all chemicals or products containing chemicals that may be considered toxic or hazardous. The MSDS's are to be forwarded to the Office of Environmental Health and Safety upon completion of the project.

1.23 INSTRUCTION OF PERSONNEL

- A. The HVAC Subcontractor shall provide free on site instruction in the proper use of installed equipment to designated representatives of the Owner, sufficient to ensure safe, secure, efficient, non-failing utilization, and operation of systems. This instruction shall include the following:
 - 1. One Site Training: Provide a minimum of 24 hours of training for owner's staff. Submit a syllabus to the Engineer prior to the first session.
 - 2. Support: Provide a minimum of 16 hours of support either on site or by telephone to answer operations questions.

PART 2 – (NOT USED)

PART 3 – (NOT USED)

END OF SECTION 230400

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SECTION 230500 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Transition fittings.
3. Dielectric fittings.
4. Mechanical demolition.
5. Equipment installation requirements common to equipment sections.
6. Painting and finishing.
7. Concrete bases.
8. Supports and anchorages.
9. Fire stopping.

1.2 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.
- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
- F. The following are industry abbreviations for plastic materials:
1. ABS: Acrylonitrile-butadiene-styrene plastic.
 2. CPVC: Chlorinated polyvinyl chloride plastic.
 3. PE: Polyethylene plastic.
- G. The following are industry abbreviations for rubber materials:
1. EPDM: Ethylene-propylene-diene terpolymer rubber.
 2. NBR: Acrylonitrile-butadiene rubber.

1.3 SUBMITTALS

A. Product Data: For the following:

1. Transition fittings.
2. Dielectric fittings.
3. Roof Curbs

B. Welding certificates.

1.4 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for Mechanical Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified, at the expense of the Contractor installing the mechanical equipment. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.6 COORDINATION

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

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for mechanical items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 8 Section "Access Doors and Frames."

D. Provide coordination drawings as specified in section 230000.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified.
 - a. Custom Curb
 - b. Pate Co. (Basis of Design)
 - c. ThyCurb

2.2 ROOF CURBS, PIPE CURBS AND ROOF PIPE SUPPORTS

A. Prefabricated Roof Curbs:

1. Roof Curbs and Equipment Supports:

Minimum 18 gauge galvanized steel, continuous welded seams, mitered corners, wood nailer, strip, 12 inches minimum height and vertical counterflashing with lag screws. Where curb is used for equipment support, provide internal reinforcing as required to support equipment load and integral base plates. Where curb is around a roof penetration, provide 1-1/2 inch thick, 3 lb. density rigid fiberglass insulation. Where curb is installed on a pitched roof, curb shall be sloped to match roof pitch. Provide raised cant to accommodate the roof insulation thickness. Pate Company ES-2.

2. Pipe Curb:

For vents or other piping passing through the roof, use a Pate Company PCA-2 curb with PCC pipe curb cover. Provide 1-1/2 inch thick, 3 lb. density rigid fiberglass insulation. Cover to be complete with graduated neoprene boots with stainless steel clamps.

B. Roof Pipe Supports

1. Roof pipe supports shall be free standing, black, lexan, pillow block pipe stands. Pipe stands shall have a "V" shape cradle, curved base edges and corners, stacking pins for secure stacking for height adjustment, vent tunnels to prevent condensate buildup and guide holes at top of cradle for installation of pipe strap.
2. Treated wood blocking for pipe support is not acceptable.

2.3 PIPE, TUBE, AND FITTINGS

- A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.

- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.4 JOINING MATERIALS

- A. Refer to individual Division 23 piping Sections for special joining materials not listed below.
- B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
 - 2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
- C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.
- G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- H. Grooved Joints: Use lubricant supplied by the coupling manufacturer and suitable for the elastomer and fluid media.

2.5 TRANSITION FITTINGS

- A. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.
- B. Manufacturers:
 - 1. Cascade Waterworks Mfg. Co.
 - 2. Dresser Industries, Inc.; DMD Div.
 - 3. Ford Meter Box Company, Incorporated (The); Pipe Products Div.
 - 4. JCM Industries.
 - 5. Smith-Blair, Inc.
 - 6. Viking Johnson.
 - 7. Victaulic Co. of America

- C. Underground Piping NPS 1-1/2 and Smaller: Manufactured fitting or coupling.
- D. Underground Piping NPS 2 and Larger: AWWA C219, metal sleeve-type coupling.
- E. Aboveground Pressure Piping: Pipe fitting.
- F. Plastic-to-Metal Transition Fittings: CPVC and PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one (1) end with threaded brass insert, and one solvent-cement-joint end.
- G. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one (1) end with threaded brass insert, and one (1) solvent-cement-joint end.
- H. Plastic-to-Metal Transition Unions: MSS SP-107, CPVC and PVC four (4) part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.
- I. Flexible Transition Couplings for Underground Nonpressure Drainage Piping: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.

2.6 DIELECTRIC FITTINGS

- A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
- B. Insulating Material: Suitable for system fluid, pressure, and temperature.
- C. Dielectric Unions: Factory-fabricated, union assembly, for 250 psig minimum working pressure at 200 deg F.
 - 1. Manufacturers:
 - a. Capitol Manufacturing Co.
 - b. Central Plastics Company.
 - c. Epco Sales, Inc.
 - d. Hart Industries, International, Inc.
 - e. Watts Industries, Inc.; Water Products Div.
 - f. Zurn Industries, Inc.; Wilkins Div.
- D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150 psig minimum working pressure as required to suit system pressures.
 - 1. Manufacturers:
 - a. Capitol Manufacturing Co.
 - b. Central Plastics Company.
 - c. Epco Sales, Inc.
 - d. Watts Industries, Inc.; Water Products Div.

- E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
 - 1. Manufacturers:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Central Plastics Company.
 - d. Pipeline Seal and Insulator, Inc.
- F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.
- G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.
 - 1. Manufacturers:
 - a. Perfection Corp.
 - b. Precision Plumbing Products, Inc.
 - c. Sioux Chief Manufacturing Co., Inc.
 - d. Victaulic Co. of America.
 - 2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

2.11 FIRE STOPPING

- A. Description: UL-classified Systems; C-AJ or W-L-7001-7999. Type of fill materials; one or both of the following: Latex sealant or mortar.

PART 3 - EXECUTION

3.1 ROOF WORK

- A. The General Contractor shall provide roof openings where indicated on the architectural drawings and where specifically coordinated with the HVAC contractor. All additional steel support framing that is required for roof penetrations shall be provided by HVAC Contractor except where indicated on the structural design drawings.
- A. The HVAC Contractor shall coordinate the size and location of all roof curbs.

- B. The HVAC Contractor shall install all roof curbs and pipe supports. Secure curbs and supports to roof deck by means of screws bolts and inserts.

3.2. PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping to permit valve servicing.
- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

New Piping:

1. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
2. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
3. Insulated Piping: One-piece, stamped-steel type with spring clips.
4. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
5. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.

6. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast- brass type with polished chrome-plated finish.
 7. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed hinge and spring clips.
 8. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
 9. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
- M. Sleeves are not required for core-drilled holes.
- N. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
1. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
 3. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 7 Section "Joint Sealants" for materials and installation.
- O. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
1. Install steel pipe for sleeves smaller than 6 inches in diameter.
 2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
 3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- P. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Piping is to be positioned in the center of the sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- Q. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 7 Section "Through-Penetration Firestop Systems" for materials.

- R. Verify final equipment locations for roughing-in.
- S. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.3 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32, wiped smooth.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate Teflon tape or Permatex pipe thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.4 PIPING CONNECTIONS

- A. Make connections according to the following, unless otherwise indicated:
 - 1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - 2. Install flanges or mechanically grooved couplings in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
 - 3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.

4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- C. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- D. Install equipment to allow right of way for piping installed at required slope.

3.6 PAINTING

- A. All general painting of piping, insulation, and equipment, if any, will be performed by the Contractor. Unless otherwise noted, where this contractor has cut finished building surfaces, this contractor shall patch and paint these surfaces.

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Division 5 Sections for structural steel.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.8 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

- A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor mechanical materials and equipment.
- B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.
- C. Attach to substrates as required to support applied loads.

3.10 FIRE STOPPING

- A. Provide fire stopping for all mechanical penetrations of all fire rated construction such as walls and floors.

3.11 DRAIN PIPING

- A. Extend drain piping from all drains and cooling coil discharge all at new air conditioning units, etc. to spill over the nearest floor drain or janitor's receptor.
- B. Provide valved blowoff on all strainers and pipe to floor drain; where no sizes are shown, blowoff shall be full size of strainer connection.

END OF SECTION 230500

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SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC SYSTEMS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes basic requirements for factory-installed and field-installed motors.

1.3 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.

1.4 DEFINITIONS

- A. Factory-Installed Motor: A motor installed by motorized-equipment manufacturer as a component of equipment.
- B. Field-Installed Motor: A motor installed at Project site and not factory installed as an integral component of motorized equipment.

1.5 SUBMITTALS

- A. Product Data for Field-Installed Motors: For each type and size of motor, provide nameplate data and ratings; shipping, installed, and operating weights; mounting arrangements; size, type, and location of winding terminations; conduit entry and ground lug locations; and information on coatings or finishes.
- B. Shop Drawings for Field-Installed Motors: Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Include the following:
 - 1. Each installed unit's type and details.
 - 2. Nameplate legends.
 - 3. Diagrams of power and control wiring. Provide schematic wiring diagram for each type of motor and for each control scheme.
- C. Qualification Data: For testing agency.
- D. Test Reports: Written reports specified in Parts 2 and 3.
- E. Operation and Maintenance Data: For field-installed motors to include in emergency,

operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, with the experience and capability to conduct the testing indicated, as documented according to ASTM E 548.
- B. Source Limitations: Obtain field-installed motors of a single type through one source from a single manufacturer.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with NFPA 70.

1.7 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices. Provide motors that are:
 - 1. Compatible with the following:
 - a. Magnetic controllers.
 - b. Multi-speed controllers.
 - 2. Designed and labeled for use with variable frequency controllers, and suitable for use throughout speed range without overheating.
 - 3. Matched to torque and horsepower requirements of the load.
 - 4. Matched to ratings and characteristics of supply circuit and required control sequence.
- B. Coordinate motor support with requirements for driven load; access for maintenance and motor replacement; installation of accessories, belts, belt guards; and adjustment of sliding rails for belt tensioning.

PART 2 - PRODUCTS

2.1 MOTOR REQUIREMENTS

- A. Motor requirements apply to factory-installed and field-installed motors except as follows:
 - 1. Different ratings, performance, or characteristics for a motor are specified in another Section.
 - 2. Manufacturer for a factory-installed motor requires ratings, performance, or characteristics, other than those specified in this Section, to meet performance specified.
- B. Comply with Energy Independence and Security Act of 2007.
- C. Comply with NEMA MG 1 table 12-11 unless otherwise noted.

- D. Comply with IEEE 847 for Severe-Duty motors.

2.2 MOTOR CHARACTERISTICS

- A. Motor Phase: As indicated on drawings.
- B. Frequency Rating: 60 Hz.
- C. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected.
- D. Service Factor: 1.15.
- E. Duty: Continuous duty at ambient temperature of 105 deg F and at an altitude of 3300 feet above sea level.
- F. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
- G. Enclosure: Open drip proof for interior mounted motors. Totally enclosed fan cooled for exterior mounted motors.

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Premium efficiency.
- C. Stator: Copper windings, unless otherwise indicated.
 - 1. Multi-speed motors shall have separate winding for each speed.
- D. Rotor: Squirrel cage, unless otherwise indicated.
- E. Bearings: Double-shielded, pre-lubricated ball bearings suitable for radial and thrust loading.
- F. Temperature Rise: Match insulation rating, unless otherwise indicated.
- G. Insulation: Class F, unless otherwise indicated.
- H. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - 1. Designed with critical vibration frequencies outside operating range of controller output.
 - 2. Temperature Rise: Matched to rating for Class B insulation.
 - 3. Insulation: Class H.
 - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
 - 5. Motor shall be design for vector or inverter-duty service with design resistant to

transient spikes, high frequencies and short time rise pulse produced by inverters.

6. Motor manufacture shall ensure specified motor operational and performance characteristics are suitable for inverter drive operation.
7. Motor shall be provided with minimum of one shaft mounted grounding protection ring to discharge pulse width modulation induced shaft voltages and bearing currents in reducing the effects of bearing pitting and scoring.
8. Motor shall include factory wired internal automatic reset high temperature thermal protector switch wired to over sized motor terminal box.

- I. Rugged-Duty Motors: Totally enclosed, with 1.15 minimum service factor, greased bearings, integral condensate drains, and capped relief vents. Windings insulated with nonhygroscopic material.

1. Finish: Chemical-resistant paint over corrosion-resistant primer.

2.4 SINGLE-PHASE MOTORS

- A. Type: One of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split-phase start, capacitor run.
3. Capacitor start, capacitor run.

- B. Shaded-Pole Motors: For motors 1/20 hp and smaller only.

- C. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

- D. Bearings: Ball type for belt-connected motors and other motors with high radial forces on motor shaft; sealed, pre-lubricated-sleeve type for other single-phase motors.

- E. Source Quality Control: Perform the following tests on each motor according to NEMA MG 1:

1. Measure winding resistance.
2. Read no-load current and speed at rated voltage and frequency.
3. Measure locked rotor current at rated frequency.
4. Perform high-potential test.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive field-installed motors for compliance with requirements, installation tolerances, and other conditions affecting performance.
- B. Examine roughing-in of conduit systems to verify actual locations of conduit connections before motor installation.

- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 MOTOR INSTALLATION

- A. Anchor each motor assembly to base, adjustable rails, or other support, arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and align with load transfer link.
- B. Wiring of motor to controller and auxiliary controls and/or safeties shall be in accordance with motor controller manufacture instructions, NFPA 70 and local code requirements.
- C. Properly ground all equipment according to controller manufacturer's requirements regarding noise attenuation and electromagnetic interference. Where not specifically specified by motor controller manufacture, ground equipment according to NFPA 70.
- D. Requirements of motor T-lead conductors shall comply with Division 26 Specification 260519 "Wires and Cable".

3.3 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Run each motor with its controller. Demonstrate correct rotation, alignment, and speed at motor design load.
 - 2. Test interlocks and control features for proper operation.
 - 3. Verify that current in each phase is within nameplate rating.
- B. Testing: Perform the following field quality-control testing:
 - 1. Perform each electrical test and visual and mechanical inspection stated in NEMA ATS, Section 7.15.1. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.4 ADJUSTING

- A. Align motors, bases, shafts, pulleys and belts. Tension belts according to manufacturer's written instructions.

3.5 CLEANING

- A. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. Clean motors, on completion of installation, according to manufacturer's written instructions.

END OF SECTION 230513

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SECTION 230515 - GENERAL PIPING REQUIREMENTS

PART 1 - GENERAL

1.1 PIPING SYSTEMS - GENERAL

- A. The following instructions apply to all piping systems, except where otherwise noted.
 - 1. Provide unions or flanges at each final connection and at each piece of equipment.
 - 2. Make connections to equipment as detailed on the Drawings or per manufacturer's installation instructions.
 - 3. Where connection size is smaller than piping, make reduction at final connection only (Do not reduce size of pipe drop).
 - 4. Provide valves and specialties as required, to complete installation of each piece of equipment, for proper operation.
- B. Clean out and flush water piping systems.
- C. If other means of draining are not provided, install drain valves at all low points to permit complete draining of each water system.
- D. Certified Pipe Welding Bureau. Welds to be stamped at each joint or fitting.
- E. Install dielectric unions at all connections of dissimilar metals.

PART 2 - PRODUCTS

2.1 COPPER PIPE

- A. Copper pipe to be of type and thickness as specified in Section 232113. Fittings shall be wrought copper fittings with soldered ends designed for 150 psi (steam) and 300 psi (water) pressure. All joints and fittings shall comply with the latest edition of ASME code for pressure piping. 2-1/2 inches and larger equipment and valved connections shall be flanged.
- B. In domestic water piping, all soldered joints shall be made with lead-free nickel silver solder for 150 psi, 250 deg F.

2.2 BLACK STEEL PIPE

- A. Steel pipe to be of type specified in Section 232113. For welded piping 1-1/2 inches and smaller, pipe shall be butt welded steel. Larger pipe shall be seamless steel or electric resistance welded. Pipe thickness shall be as scheduled in the specifications. All joints and fittings shall comply with the latest edition of ASME code for pressure piping.
- B. Threaded pipe shall be accurately cut NPT tapered right hand threads. Screwed fittings shall be of the same make and thickness for weight as the pipe used.
- C. Butt weld pipe joints shall be butt type, single vee made by fusion welding oxy-acetylene, electric welding using high test welding rod or semi-automatic metal arc welding machines using micro-wire. Branches in straight pipe are to be made with welding tees of same make and thickness of weight as the pipe used. Branches 1/4 the size of the main or less

may be made with weld neck flanges, weld-o-let=s or thread-o-let fittings. Elbows shall be long radius.

- D. Socket weld pipe joints shall be made using 2000 lb. socket weld steel fittings. All other items shall be per part 2.2, paragraph C this section of specifications.
- E. Flanged pipe: Connections to valves, equipment, etc. shall be made with 125 - 150 lb. standard flanges, except for 250 - 300 lb. extra heavy flanges or fitting on valves, equipment, etc. furnished with extra heavy flanges. Flanged joints are to be faced square and true.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Each union or flange be installed to permit easy removal of parts and equipment, and in a position permitting the device or equipment to be removed without disconnecting piping. Connections to equipment shall be arranged to facilitate ease of removal and service without dismantling of the run-outs of main piping, and shall be installed by the use of multiple elbows or other similar methods to minimize strain on the equipment connections.
- B. Make reductions in piping lines with reducing coupling or weld fitting reducer.
- C. Install piping to provide clearance for personnel passage, headroom, operation of doors or windows, equipment, lighting outlets, or with Owner's apparatus and equipment.
- D. In pipe spaces to be entered for servicing, piping shall be offset so that all lateral runs are located either near floor or 6'-0" above floor and all vertical piping is held close to the wall through that height. Keep all piping to side of chase wherever possible.
- E. Piping containing liquids shall not be installed over electrical equipment.
- F. Install pipes, valves, fittings, etc. to be insulated with a minimum of 1/2-inch clearance between the finished covering and other work and between the finished covering of parallel, adjacent pipes.
- G. Make changes in pipe line direction with fittings only.
- H. Offset lines around columns, beams and other obstructions as required. Where special conditions are encountered in field, arrangement and alignment of piping shall be decided by the Owner's Representative.
- I. At time of erection, piping components shall be cleaned of loose material. After erection, and prior to putting in service, lines shall be blown or flushed free of loose materials. Clean strainer screens and sediment pockets prior to putting lines in service.
- J. Install valves at service connections to equipment and branch lines from main lines. All valves and unions to be installed so as to be accessible through ceiling or wall access panel.
- K. Contractor is responsible for conformance with all applicable requirements for welding and burning. Contractor shall obtain all necessary permits.

- L. SECURELY SUPPORT all piping from structure with approved hangers, rods, brackets and accessories.
- M. Where piping is installed in new masonry block walls, coordinate with General Contractor so piping extends out through a masonry joint where possible.
- N. Bullhead fittings are not allowed.
- O. Where exposed pipes pass through walls, floors or ceilings of finished rooms, provide chrome-plated escutcheons. Prime-coated black iron escutcheons may be used in unfinished rooms. Protect escutcheons from tool marks.
- P. Keep pipe level except where a slope is required. Use eccentric reducers to keep top of pipe level.
- Q. Avoid trapping of piping.
- R. Use transition fittings as recommended by manufacturers to change from one pipe material or type to another.
- S. All new piping during the installation period shall have openings protected with temporary caps or protective covers as required to keep the inside of the piping system clean from all dirt, debris and foreign material.
- T. At completion of project, thoroughly flush each of the various HVAC hydronic circulating systems with a cleaning solution as recommended by the chemical supplier and the various material manufacturers, so as to remove any oil, rust, dirt, scale or grease that may be present.
- U. Do not obstruct passageways, headroom, door and window operation, and similar areas with the installation of piping.

3.2 PIPING PROHIBITIONS

- A. Contractor shall not run piping over electrical panels, across windows, door openings, access panels, lighting fixture or within 36 inches in front of electrical panels. Obtain instructions from the Architect if a conflict occurs.
- B. On any given system, the Contractor will not be permitted to mix and joint different types of pipe material. For example, if a hot water heating system uses copper and steel, the Contractor may change from one to the other only once, the line may not be changed back to the first material further downstream.
- C. Drain lines shall be continuously sloped; trapping is expressly prohibited.

END OF SECTION 230515

SECTION 230516 – EXPANSION TANKS FOR HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Expansion Tanks

1.3 SUBMITTALS

- 1. Product Data: For each product indicated.
- 2. Shop Drawings: Show tank layout and piping connections.
- B. Operation and Maintenance Data: For expansion tanks include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain expansion tanks through one source from a single manufacturer.
- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of expansion tanks and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.
- B. Store expansion tanks in dry location.
- C. Retain protective covers for flanges and protective coatings during storage.
- D. Protect expansion tanks against damage from sand, grit, and other foreign matter.
- E. Comply with expansion tanks manufacturer's written rigging instructions.

1.6 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.1 EXPANSION TANKS

- A. Tanks shall be of pre-pressurized, diaphragm type welded steel construction, designed for 125 PSI working pressure, 240°F. operating temperature and made airtight and tested under water at 225 PSI. Tanks shall be constructed in accordance with ASME Code for Unfired Pressure Vessels and shall be so certified and stamped. The tanks shall be of vertical type equipped with integral support ring for mounting on concrete pad.
- B. Dual Temperature Water System
 - 1. Tank(s) shall be Taco Type CA, Armstrong, Armtrol, Bell & Gossett, or approved equal, pre-pressurized, diaphragm expansion tank as scheduled on drawings. The tank shall be equipped with tappings for expansion line inlet, drain, and charging port. Factory charge tank to pressure indicated on drawings.
- C. Relief Valve
 - 1. In each expansion line install a ball valve, automatic air vent, and a Watts Regulator Co., Bell & Gossett, Cash, or equal, $\frac{3}{4}$ " ASME approved pressure relief valve set at 100 PSIG.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of work.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before tank installation.
- C. Examine foundations for suitable conditions where tanks are to be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONCRETE BASES

- A. Install concrete bases of dimensions indicated for pumps and controllers. Refer to Division 23 Section "Common Work Results for HVAC".
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of based.
 - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
- B. Cast-in-place concrete materials and placement requirements are specified in Division 03.

3.3 TANK INSTALLATION

- A. Install tanks with access for periodic maintenance.
- B. Independently support tanks and piping so weight of piping is not supported by tanks and weight of tanks is not supported by piping.
 - 1. Set tanks on concrete foundation.

3.4 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to tank to allow service and maintenance.
- C. Connect piping to tanks. Install valves that are same size as piping connected to tanks.
- D. Install relief valve in each expansion line.

END OF SECTION 23 05 16

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SECTION 230517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Sleeves.
 - 2. Stack-sleeve fittings.
 - 3. Sleeve-seal systems.
 - 4. Sleeve-seal fittings.
 - 5. Grout.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
- C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- D. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.2 STACK-SLEEVE FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Smith, Jay R. Mfg. Co.
2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.

B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).
4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc.

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Presealed Systems.

C. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

- C. Design Mix: 5000-psi , 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
 - 1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
- D. Cut sleeves to length for mounting flush with both surfaces.
 - 1. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
 - 2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- E. Install sleeves for pipes passing through interior partitions.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 - 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Division 07 Section "Joint Sealants."
- F. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07 Section "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
 - 1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.

- B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07 Section "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 - 1. Exterior Concrete Walls above Grade:
 - a. Piping Smaller Than NPS 6: Cast-iron wall sleeves, Galvanized-steel wall sleeves, or Galvanized-steel-pipe sleeves.
 - b. Piping NPS 6 and Larger: Cast-iron wall sleeves, Galvanized-steel wall sleeves, or Galvanized-steel-pipe sleeves.
 - 2. Exterior Concrete Walls below Grade:
 - a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system, Galvanized-steel wall sleeves with sleeve-seal system, or Galvanized-steel-pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system, Galvanized-steel wall sleeves with sleeve-seal system, or Galvanized-steel-pipe sleeves with sleeve-seal system.

- 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
3. Concrete Slabs above Grade:
 - a. Piping Smaller Than NPS 6 Galvanized-steel-pipe sleeves, Stack-sleeve fittings, Sleeve-seal fittings
 - b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves, Stack-sleeve fittings.
4. Interior Partitions:
 - a. Piping Smaller Than NPS 6 Galvanized-steel-pipe sleeves,
 - b. Piping NPS 6 and Larger: Galvanized-steel-sheet sleeves.

END OF SECTION 230517

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SECTION 230518 - ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Escutcheons.
 - 2. Floor plates.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

- A. One-Piece, Cast-Brass Type: With rough brass finish and setscrew fastener.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
- C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.
- D. Split-Casting Brass Type: With rough-brass finish and with concealed hinge and setscrew.
- E. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed hinge, and spring-clip fasteners.

2.2 FLOOR PLATES

- A. One-Piece Floor Plates: Cast-iron flange.
- B. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. Escutcheons for New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
 - c. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with rough brass finish.
 - d. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
 - e. Bare Piping in Equipment Rooms: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
 - 2. Escutcheons for Existing Piping:
 - a. Insulated Piping: Split-plate, stamped-steel type with concealed hinge.
 - b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting brass type with rough brass finish.
 - c. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting brass type with rough brass finish.
 - d. Bare Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed hinge.
 - e. Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with concealed hinge.
- C. Install floor plates for piping penetrations of equipment-room floors.
- D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. New Piping: One-piece, floor-plate type.
 - 2. Existing Piping: Split-casting, floor-plate type.

3.2 FIELD QUALITY CONTROL

- A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 230518

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SECTION 230519 - METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following meters and gages for mechanical systems:
 - 1. Thermometers.
 - 2. Gages.
 - 3. Test plugs.

1.2 DEFINITIONS

- A. CR: Chlorosulfonated polyethylene synthetic rubber.
- B. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated; include performance curves.
- B. Shop Drawings: Schedule for thermometers and gages indicating manufacturer's number, scale range, and location for each.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified.

2.2 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS

- A. Manufacturers:
 - 1. Palmer - Wahl Instruments Inc.
 - 2. Trerice, H. O. Co.
 - 3. Weiss Instruments, Inc.
 - 4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
- B. Type: Liquid-in-glass type, 9 inch long of chrome plated brass construction or self-powered digital type with glass passivated thermistor and internal potentiometer.
- C. Tube: Red reading, liquid filled, with magnifying lens. The use of mercury shall be prohibited.
- D. Tube Background: Satin-faced, non-reflective aluminum with permanently etched scale markings.

- E. Window: Clear acrylic held in place with removable stainless steel cap.
- F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.
- G. Stem: Brass for thermowell installation and of length to suit installation.
- H. Accuracy: Plus or minus 1 scale division to maximum of 1.5 percent of range.

2.3 THERMOWELLS

- A. Manufacturers: Same as manufacturer of thermometer being used.
- B. Description: Pressure-tight, socket-type brass or stainless steel fitting made for insertion into piping and of type, diameter, and length required to hold thermometer. Thermowell to have a two inch extension with threaded cap nut and cap for all insulated piping.

2.4 PRESSURE GAGES

- A. Manufacturers:
 - 1. Palmer - Wahl Instruments Inc.
 - 2. Terice, H. O. Co.
 - 3. Weiss Instruments, Inc.
 - 4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
- B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.
 - 1. Case: Dry or Glycerine filled type, 4-1/2 inch diameter.
 - 2. Pressure-Element Assembly: Stainless Steel, Bourdon tube.
 - 3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type.
 - 4. Movement: Mechanical, with link to pressure element and connection to pointer.
 - 5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
 - 6. Pointer: Black metal.
 - 7. Window: Glass.
 - 8. Ring: Stainless Steel.
 - 9. Accuracy: Grade 2A, plus or minus 0.5 percent of scale range.
 - 10. Range for Fluids under Pressure: Two (2) times operating pressure.
 - 11. Provide gauges without back mounting plate.
 - 12. Vacuum Range: 30 inches HG of vacuum to 15 PSIG of pressure.

2.5 TEST PLUGS

- A. Manufacturers:
 - 1. Peterson Equipment Co., Inc.
 - 2. Sisco Manufacturing Co.
 - 3. Terice, H. O. Co.
 - 4. Watts Industries, Inc.; Water Products Div.
- B. Description: 1/2 inch NPT, Corrosion-resistant brass body with core inserts and

gasketed and threaded cap, with extended stem for units to be installed in insulated piping.

- C. Minimum Pressure and Temperature Rating: 1000 psi at 350 deg F.
- D. Core Inserts: Two (2) self-sealing rubber valves.
 - 1. Insert material for air, water, oil, or gas service at 20 to 350 deg F shall be Nordel.
- E. Test Kit: Furnish one (1) test kit containing one (1) pressure gage and adaptor, two (2) thermometers, and carrying case. Pressure gage, adapter probes, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.
 - 1. Pressure Gage: Small bourdon-tube insertion type with 2- to 3- inch diameter dial and probe. Dial range shall be 0 to 200 psig.
 - 2. Low Range Thermometer: Small bimetallic insertion type with 2 inch diameter dial and tapered-end sensing element. Dial ranges shall be 0 to 220 deg F.
 - 3. Carrying case shall have formed instrument padding.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

- A. Install liquid-in-glass thermometers in the following locations:
 - 1. Where indicated on the design drawing piping diagrams.
 - 2. Inlet and outlet of each hydronic boiler and chiller.
 - 3. Inlet and outlet of air handling unit heating & cooling coils.
- B. Provide the following temperature ranges for thermometers:
 - 1. Heating Hot Water: 30 to 200 deg F, with 2-degree scale divisions.
 - 2. Chilled Water: 0 to 100 deg F, with 2-degree scale divisions.

3.2 GAGE APPLICATIONS

- A. Install dry-case-type pressure gages for discharge of each pressure-reducing valve.
- B. Install liquid-filled-case-type pressure gages at chilled water inlet and outlet of chiller and boiler.
- C. Install liquid-filled-case-type pressure gages at suction and discharge of each pump.

3.3 TEST PLUG APPLICATIONS

- A. Inlet and outlet of each heating and cooling coil.
- B. Inlet and outlet of each strainer on coils.

- C. Inlet and outlet of each temperature regulating valve.
- D. Inlet and outlet of each pressure reducing valve.
- E. Both inlets to differential pressure transmitters.

3.4 INSTALLATIONS

- A. Install direct-mounting thermometers and adjust vertical and tilted positions.
- B. Install thermowells with socket extending to center of pipe and in vertical position in piping tees where thermometers are indicated.
- C. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.
- D. Install needle-valve and snubber fitting in piping for each pressure gage for fluids.
- E. Install test plugs in tees in piping. Install test plugs with sufficient clearance to permit installation of test gauges and thermometers.

3.5 CONNECTIONS

- A. Install meters and gages adjacent to machines and equipment to allow service and maintenance for meters, gages, machines and equipment.

3.6 ADJUSTING

- A. Adjust faces of meters and gages to proper angle for best visibility.

END OF SECTION 230519

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SECTION 230523 – GENERAL DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide valves to facilitate maintenance and isolation of piping systems.

1.2 QUALITY ASSURANCE

A. STANDARDS

1. American National Standards Institute (ANSI), American Society of Mechanical Engineers (ASME), American Society for Testing and Materials (ASTM) and the Manufacturers' Standardization Society of the Valve and Fittings Industry (MSS).
 2. ANSI B16.10, MSS SP0-67-90 Butterfly Valves.
 3. MSS SP-70-90 Cast Iron Gate Valves, Flanged or Threaded Ends.
 4. MSS SP-78-92 Cast Iron Plug Valves Flanged and Threaded.
 5. MSS SP-80-87 Bronze Gate, Globe, and Check Valves.
 6. MSS SP-85-85 Cast Iron Globe and Angle Valves, Flanged and Threaded Ends.
 7. MSS SP-110-92 Ball Valves Threaded, Socket-Welded, Solder Joint, Grooved and Flared Ends.
- B. To assure uniformity and compatibility of piping components in grooved end piping systems, all grooved products utilized shall be supplied by the same manufacturer.

1.3 DEFINITIONS

- A. The following are standard abbreviations for valves:

1. CWP: Cold working pressure.
2. EPDM: Ethylene-propylene-diene terpolymer rubber.
3. NBR: Acrylonitrile-butadiene rubber.
4. PTFE: Polytetrafluoroethylene plastic.
5. OS & Y: Outside screw and yoke.
6. RS: Rising stem.
7. SWP: Steam working pressure.
8. TFE: Tetrafluoroethylene plastic.

1.4 SUBMITTALS

- A. Product Data: For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
 2. Protect threads, flange faces, grooves, and weld ends.
 3. Set angle, gate, and globe valves closed to prevent rattling.
 4. Set ball and plug valves open to minimize exposure of functional surfaces.
 5. Set butterfly valves closed or slightly open.
 6. Block check valves in either closed or open position.
- B. Use the following precautions during storage:
1. Maintain valve end protection.
 2. Store valves indoors and maintain at higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use hand wheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. All similar valves used on the project shall be by the same manufacturer.
- B. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified.

2.2 VALVES, GENERAL

- A. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- B. Valve Sizes: Same as upstream pipe, unless otherwise indicated.
- C. Valve Actuators:
1. Chainwheel: For attachment to valves, of size and mounting height, as indicated in the "Valve Installation" Article in Part 3.
 2. Gear Drive: For quarter-turn valves NPS 6 and larger and on discharge of all pumps without VFD's.
 3. Handwheel: For valves other than quarter-turn types.
 4. Lever Handle: For quarter-turn valves NPS 5 and smaller, except plug valves.
 5. Wrench: For plug valves with square heads. Furnish Owner with one (1) wrench for every ten (10) plug valves, for each size square plug head.
- D. Extended Valve Stems: On insulated valves.
- E. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves and ASME B16.24 for bronze valves.
- F. Valve Grooved Ends: AWWA C606.

- G. Solder Joint: With sockets according to ASME B16.18. Caution: Use solder with melting point below 840 deg F for angle, check, gate, and globe valves; below 421 deg F for ball valves.
- H. Threaded Joint: With threads according to ASME B1.20.1.
- G. Valve Bypass and Drain Connections: MSS SP-45.

2.3 GATE VALVES (USED ONLY WHERE INDICATED)

- A. Four inches and larger gate valves in steel pipe shall be iron body, bronze mounted, outside screw and yoke, flanged bonnet, rising stem, solid wedge. Rated at 200 psi WOG; 125 psi steam: Powell Fig 1793.
- B. Manufacturers:
 - 1. Powell (Basis of Design)
 - 2. Milwaukee
 - 3. Lunkenheimer
 - 4. Nibco
 - 5. Hammond

2.4 BALL VALVES (2-1/2 INCHES AND SMALLER)

- A. 400 psi WOG, 150 psi steam, bubble-tight against 100 psi, cast bronze body, self-aligning free floating stainless steel ball and stem with full flow port, non-rising stem, Teflon seat and body seal, quarter turn operation, solder joint or screwed ends. Valves to include memory stop and stem extensions for insulated piping.
 - 1. Drain valves with hose fitting, dust cover and chain attachment: Apollo No. 78-144
 - 2. All other valves: Apollo No. 77-140/240
 - 3. Manufacturers:
 - a. Apollo (Basis of Design)
 - b. Hammond
 - c. Milwaukee
 - d. Nibco
 - e. Watts
 - f. Victaulic Co. of America
- B. Two-Piece Standard Port Ductile Iron Ball Valve, (Sizes 2 inch to 2-1/2 inch):
 - 1. Manufacturer:
 - a. Victaulic Company Series 726

2. Description:

- a. Standard: MSS SP-72.
- b. CWP Rating: 800 psig
- c. Body Material: ASTM A 536 Ductile Iron
- d. Ends: Grooved.
- e. Seats: TFE.
- f. Stem: Stainless steel.
- g. Ball: Stainless Steel.
- h. Port: Full port to match pipe size.

2.5 BUTTERFLY VALVES (CHILLED WATER)

- A. Chilled water butterfly valves shall be Keystone K-Lok Figure 362, DeZurick, Norris, Demco, Crane, Watts, Ginnell, or approved equal high performance butterfly valves suitable for 200° F at a system shutoff pressure of 740 PSI.

1. Valves shall have carbon steel body with full lug type body with holes drilled and tapped for 150 PSI flanges, stainless steel shaft and disc, stainless steel/nitride bearings, and with EPDM seat.
2. Valves 6" and larger at valves at pump discharge shall be equipped with enclosed gear operators; smaller valves shall be equipped with notched plate and rotary handle.

2.6 BUTTERFLY VALVES (3 INCHES AND LARGER)

- A. 225 psi line pressure, bubble-tight bi-directionally against 225 psi differential pressure, 250 psi dead end pressure, cast iron lugged type body, double-seated, stainless steel disc, with EPDM seat, stainless steel shaft, bronze bushings, 200° F maximum water temperature.

1. 12 inches and smaller: Keystone Fig. 22
2. 14 inches and larger : Keystone Fig. AR2

- B. Manufacturers:

1. DeZurik
2. Keystone (Basis of Design)
3. Milwaukee
4. Nibco
5. Norris
6. Watts

2.7 CHECK VALVES

- A. Pump discharge and vertical piping

1. Semi-steel body, bronze mounted, anti-water hammer type
 - a. 2-1/2 inches and smaller: Williams No. 329
 - b. 3 inches and larger: Williams No. 636
 - c. Manufacturers:

- 1) McAlear
- 2) Mission
- 3) Mueller
- 4) Williams (Basis of Design)
- 5) Victaulic Co. of America

- B. 2 inches and smaller: 200 psi WOG, bronze swing check, solder joint tubing ends or threaded ends with replaceable composition disc and integral seat.
1. 2 inches and smaller in copper pipe: Powell Fig. 1825
 2. 2 inches and smaller in steel pipe: Powell Fig. 560
- C. 2-1/2 inches and larger: 200 psi WOG, iron body bronze trim, renewable disc; Powell Fig. 559.
- D. Manufacturers:
1. Hammond
 2. Lunkenheimer
 3. Powell (Basis of Design)
 4. Victaulic Co. of America

2.9 CALIBRATED BALANCING VALVES

- A. Bell & Gossett Circuit Setter Plus or equal by Armstrong, Taco, Tour & Andersson, Flowset with positive shut-off, memory stop screw or 4-turn digital readout handwheel, drain connection, read-out valves with EPT insert and check valve, insulated cover, bronze or Ametal brass body, brass ball or globe type, carbon filled TFE or Ametal seats, calibrated name plate. Balancing valves to be 30 PSIT/250 Deg, F rated for 1/2" to 3" NPT connections, 200 PSIG/250 Deg, F rated for 1/2" to 3/4" sweat or grooved connections and 125 PSIG/250 Deg, F rated for 4" flanged or grooved connections.
- B. Furnish a portable flow measuring instrument for verifying and determining flow. Furnish carrying case, gage, valve block and color coded hoses for low and high pressure connections, and connectors for connection to read-out valves.

2.10 CHAINWHEEL ACTUATORS

- A. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
 - 1. Sprocket Rim with Chain Guides: Cast iron, of type and size required for valve.
 - 2. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
 - 3. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

2.11 AUTOMATIC BALACING VALVE

- A. Valve with cartridges that automatically control flow rates with plus or minimum 5% accuracy over an operating pressure differential range of at least 14 times the minimum required for control. Valve internal control mechanism shall consist of a stainless steel one-piece cartridge with segmented port design and full travel linear coil spring or equivalent. Body design shall allow inspection or removal of cartridge or strainer without disturbing piping connections. Provide isolation valves on both inlet and outlet side of the balancing valves that permit removal of balancing valve without drain down of piping. Valves 2-1/2 inch and smaller shall be solder or screwed ends, valves 3 inch and larger shall be flanged. Extra cartridges shall be provided as required for a 2 year to adjust system flows to meet demand.
- B. Automatic balancing valves shall not be used where modulating temperature control valves are installed.
- C. Manufacturers:
 - 1. Griswald
 - 2. Automatic Flow Control
 - 3. Armstrong

PART 3 – EXECUTION

3.1 EXAMINATION

- A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.
 - 1. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- C. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- D. Examine threads on valve and mating pipe for form and cleanliness.
- E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- F. Examine grooved ends for conditions that might cause leakage. Ends should be free from indentations or projections in the area from the valve end to the groove.

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

3.2 VALVE APPLICATIONS

- A. Refer to piping Sections for specific valve applications. If valve applications are not indicated, use the following:
 - 1. Shutoff Service: Ball valves for size 2-1/2" and less; butterfly valves for sizes 3" and larger.
 - 2. Throttling Service: Ball valves for size 2-1/2" and less; butterfly valves for sizes 3" and larger.
- B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP class or CWP ratings may be substituted.

3.3 VALVE INSTALLATION

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install valves with unions, grooved couplings or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- C. Locate valves for easy access and provide separate support where necessary.
- D. Install valves in horizontal piping with stem at or above center of pipe.
- E. Install valves in position to allow full stem movement.
- F. Install chain wheel operators on valves NPS 3 and larger and more than 96 inches above floor. Extend chains to 78 inches above finished floor elevation.
- G. Install check valves for proper direction of flow and as follows:
 - 1. Swing Check Valves: In horizontal position with hinge pin level.
 - 2. Dual-Plate Check Valves: In horizontal or vertical position, between flanges.
 - 3. Lift Check Valves: With stem upright and plumb.
- H. Provide sufficient space to allow adjustment of balancing valves.
- I. Install drain valves in piping at low points and trapped areas to provide complete drainage of all systems.

3.4 JOINT CONSTRUCTION

- A. Grooved Joints: Assemble joints with keyed coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.
- B. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated. Open valves before soldering.

3.5 ADJUSTING

- A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

END OF SECTION 230523

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SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes hangers and supports for mechanical system equipment.

1.2 DEFINITIONS

- A. MSS: Manufacturers Standardization Society for the Valve and Fittings Industry.
- B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.3 PERFORMANCE REQUIREMENTS

- A. Design channel support systems for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

1.4 SUBMITTALS

- A. Product Data: For each type of pipe hanger, channel support system component, and thermal-hanger shield insert indicated.
- B. Shop Drawings: Signed and sealed by a qualified professional engineer for multiple piping supports and trapeze hangers. Include design calculations and indicate size and characteristics of components and fabrication details.
- C. Welding Certificates: Copies of certificates for welding procedures and operators.

1.5 QUALITY ASSURANCE

- A. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified:
 - 1. Channel Support Systems:
 - a. Grinnell Corp.; Power-Strut Unit.
 - b. Michigan Hanger Co., Inc.; O-Strut Div.
 - c. National Pipe Hanger Corp.
 - d. Thomas & Betts Corp.
 - e. Unistrut Corp.
 - 2. Thermal-Hanger Shield Inserts:

- a. Michigan Hanger Co., Inc
 - b. Pipe Shields, Inc.
 - c. Rilco Manufacturing Co., Inc.
 - d. Value Engineered Products, Inc.
3. Powder-Actuated Fastener Systems:
- a. Gunnebo Fastening Corp.
 - b. Hilti, Inc.
 - c. ITW Ramset/Red Head.
 - d. Masterset Fastening Systems, Inc.

2.2 MANUFACTURED UNITS

- A. Pipe Hangers, Supports, and Components: MSS SP-58, factory-fabricated components. Refer to "Hanger and Support Applications" Article in Part 3 for where to use specific hanger and support types.
1. Galvanized, Metallic Coatings: For piping and equipment that will not have field-applied finish.
 2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- B. Channel Support Systems: MFMA-2, factory-fabricated components for field assembly.
1. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.
 2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- C. Thermal-Hanger Shield Inserts: 100 psi minimum compressive-strength insulation, encased in sheet metal shield.
1. Material for Cold Piping: ASTM C 552, Type I cellular glass with vapor barrier.
 2. Material for Hot Piping: ASTM C 552, Type I cellular glass.
 3. For Trapeze or Clamped System: Insert and shield cover entire circumference of pipe.
 4. For Clevis or Band Hanger: Insert and shield cover lower 180 degrees of pipe.
 5. Insert Length: Extend 2" beyond sheet metal shield for piping operating below ambient air temperature.

2.3 MISCELLANEOUS MATERIALS

- A. Powder-Actuated Drive-Pin Fasteners: Powder-actuated-type, drive-pin attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.
- C. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars, black and galvanized.

- D. Grout: ASTM C 1107, Grade B, factory-mixed and -packaged, nonshrink and nonmetallic, dry, hydraulic-cement grout.
 - 1. Characteristics: Post hardening and volume adjusting; recommended for both interior and exterior applications.
 - 2. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 3. Design Mix: 5000-psi 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

- A. Specific hanger requirements are specified in Sections specifying equipment and systems.
- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Specification Sections.

3.2 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure above or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

3.3 METAL FABRICATION

- A. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field-weld connections that cannot be shop-welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

- A. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

3.6 PAINTING

- A. Touching Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION 230529

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SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. IDENTIFY BY LABELS AND TAGS THE FOLLOWING ITEMS

1. Equipment such as exhaust fans, air handling units, control cabinets, VAV boxes, etc.
2. Piping, valves and ductwork exposed in equipment rooms and accessible service areas.
3. Piping, valves and ductwork running above accessible ceiling construction and near access panels in non-accessible construction areas.
4. All temperature control valves and automatic control dampers.

- B. Install laminated plastic markers and metal stamped nameplates for equipment. Provide color banding, flow arrows and contents identification for piping and ductwork.

1.2 SUMMARY

- A. This Section includes the following mechanical identification materials and their installation:

1. Equipment nameplates.
2. Equipment markers.
3. Pipe markers.
4. Duct markers.
5. Stencils.
6. Valve tags.
7. Valve Schedules.
8. Warning tags.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Valve numbering scheme.
- D. Valve Schedules: For each piping system. Furnish three extra copies (in addition to mounted copies) to include in maintenance manuals.

1.4 QUALITY ASSURANCE

- A. ASME Compliance: Comply with ASME A13.1, "Scheme for the Identification of Piping Systems," for letter size, length of color field, colors and viewing angles of identification devices for piping.

1.5 COORDINATION

- A. Coordination installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with location of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.
- D. All trades shall use the same type, style and appearance of identification.

PART 2 - PRODUCTS

2.1 EQUIPMENT IDENTIFICATION DEVICES

- A. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.
 - 1. Data:
 - a. Manufacturer, product name, model number, and serial number.
 - b. Capacity, operating and power characteristics, and essential data.
 - c. Labels of tested compliances.
 - 2. Location: Accessible and visible.
 - 3. Fasteners: As required to mount on equipment.
- B. Equipment Markers: Engraved, laminated plastic, white lettering on black background. Markers shall be screw on, except where screws might damage equipment, use a contact-type permanent adhesive.
 - 1. Terminology: Match schedules as closely as possible.
 - 2. Size: Sized for 3/4-inch lettering.

2.2 PIPING IDENTIFICATION DEVICES

- A. Manufactured Pipe Markers, General: Preprinted, color-coded, with lettering indicating service, and showing direction of flow.
 - 1. Colors: As indicated in specification schedule.
 - 2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.
 - 3. Pipes with OD, including insulation, less than 6 inches: Full-band pipe markers

extending 360 degrees around pipe at each location.

4. Pipes with OD, including insulation, 6 inches and larger: Either full-band or strip-type pipe markers at least three (3) times letter height and of length required for label.
5. Arrows: A separate unit on each pipe marker to indicate direction of flow. 2.3

2.3 DUCT IDENTIFICATION DEVICES

- A. Stencils: Prepared with minimum letter height of 1-1/4 inches for ducts.
 1. Stencil Paint: Exterior, gloss, alkyd enamel black, unless otherwise indicated. Paint may be in pressurized spray-can form.
 2. Identification Paint: Exterior alkyd enamel in colors as indicated in specification schedule.
- B. Manual dampers: Wrap duct with red plastic ribbon with 12" long tail at each manual damper.

2.4 VALVE TAGS

- A. Valve Tags: 2" diameter tag stamped or engraved with ¼-inch letters for piping system abbreviation and ½-inch numbers, with numbering scheme, approved by Engineer. Provide 5/32-inch hole for fastener.
 1. Material: 16 gauge brass.
 2. Valve-Tag Fasteners: Brass beaded chain.

2.5 VALVE SCHEDULES

- A. Valve Schedules: For each piping system, on standard-size bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulation), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 1. Valve-Schedule Frames: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Include mounting screws.
 2. Frame: Extruded aluminum.
 3. Glazing: ASTM C 1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single-thickness glass.

2.6 WARNING TAGS

- A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags; of plasticized card stock with matte finish suitable for writing.
 1. Size: Approximately 4 by 7 inches.
 2. Fasteners: Brass grommet and wire.
 3. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.
 4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 APPLICATIONS, GENERAL

- A. Products specified are for applications referenced in other Division 15 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer=s option.
- B. Installing Contractor is responsible for valve tagging, equipment markers and pipe identification of all valves, equipment and piping on packaged pumping skids.

3.2 EQUIPMENT IDENTIFICATION

- A. Install equipment markers with screws, or, if screws might damage equipment, use permanent adhesive on or near each major item of mechanical equipment.
 - 1. Locate markers where accessible and visible. Include markers for the following general categories of equipment:
 - a. Main control and operating valves, including safety devices.
 - b. Terminal VAV units.
 - c. Boilers
 - d. Pumps, chillers and similar motor-driven units.
 - e. Coils, heat recovery units and similar equipment.
 - f. Fans, blowers, primary balancing dampers, and mixing boxes.
 - g. Packaged HVAC central-station and air handling units.
 - h. Tanks and pressure vessels.
 - i. Water-treatment systems and similar equipment.

3.3 PIPING IDENTIFICATION

- A. Install manufactured pipe markers indicating service of each piping system. Install with flow indication arrows showing direction of flow.
- B. All underground pipe shall be marked with a continuous, underground-type plastic line marker. Confirm location of markers with the Engineer.
- C. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior non-concealed locations as follows:
 - 1. Near each valve and control device.
 - 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 - 3. Near penetrations through walls, floors, ceilings, and non-accessible enclosures.
 - 4. At access doors, manholes, and similar access points that permit view of concealed piping.
 - 5. Near major equipment items and other points of origination and termination.

6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings.

D. Pipe Identification:

<u>TYPE OF SERVICE</u>	1" BAND		<u>DESIGNATION</u>
	<u>COLOR</u>	<u>COLOR</u>	
Refrigerated Liquid	Yellow	Black	LIQ
Refrigerated Suction	Yellow	Black	SUCT
Chilled Water Supply	Blue	Black	CHWS
Chilled Water Return	Blue	Black	CHWR
Heating Water Supply	Lime Green	Lime Green	HWS
Heating Water Return	Lime Green	Lime Green	HWR
Dual Temp. Supply	Blue	Lime Green	DTS
Dual Temp. Return	Blue	Lime Green	DTR
Mechanical City Water	Blue	Blue	MCW

3.4 DUCT IDENTIFICATION

- A. Stenciled Duct Markers: Stenciled markers, showing service and direction of flow. Stencil only after ductwork is painted.
- B. Locate markers near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system and at access doors in concealed spaces.
- C. Duct Identification:

<u>TYPE OF SERVICE</u>	1" BAND	
	<u>COLOR</u>	<u>DESIGNATION</u>
Supply Air	Green	SUPPLY
Return Air	Blue	RETURN
Exhaust Air	Blue	EXH
Outdoor Air	Blue	OA

3.5 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; plumbing fixture supply stops; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves with captions as indicated in the following:

<u>TYPE OF SERVICE</u>	<u>VALVE TAG DESIGNATION</u>
Heating Water Supply	HWS
Heating Water Return	HWR
Chilled Water Supply	CHWS
Chilled Water Return	CHWR

Dual Temperature Supply
Dual Temperature Return
Mechanical City Water

DTS
DTR
MCW

3.6 VALVE-SCHEDULE INSTALLATION

- A. Mount valve schedule on wall in accessible location where directed by Owner. Provide aluminum frame with plexiglass cover for valve chart.

3.7 WARNING-TAG INSTALLATION

- A. Write required message on, and attach warning tags to equipment and other items where required.

3.8 ADJUSTING

- A. Relocate mechanical identification materials and devices that have become visually blocked by other work. Stencils, name tags, etc. must be readable from a standing position.
- A. When arrows and letters cannot be stenciled on pipe, stencil identification on 16 gauge aluminum metal panels in correct color and hang panel on piping with key chains.

3.9 CLEANING

- A. Clean faces of mechanical identification devices and glass and frames of valve schedules.

3.10 UNDERGROUND UTILITIES

- A. The following underground utility shall have a 3M ball marker or full-range marker, each having a distinct color and frequency, for locating underground utilities. The marker shall be used only when the utility will be 8 feet or less below the future finished grade. The marker shall be placed in the trench, on top of the utility. A marker shall be placed every 25 feet. A marker shall be placed at every direction change. There shall be a minimum of two markers for each utility trench. Each marker shall be as follows:

1. The 1253 full-range green marker for chilled water and hot water piping.

- B. Note, all underground utilities and proposed areas of excavation shall be marked in strict accordance with Ohio's Universal Marketing Standards.

END OF SECTION 230553

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SECTION 230593 - TESTING ADJUSTING AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. The testing, adjusting and balancing work as specified in this section is to be performed by a certified balancing contractor that is hired by the HVAC Contractor. All final tab work will be completed at the end of the final phase of work. The HVAC Contractor is to provide all necessary assistance and coordination with the testing, adjusting and balancing, (TAB) contractor as required to complete the balancing work and generate the balancing report as specified in this section. The HVAC Contractor is to provide all system start-up procedures and commissioning tasks that are required prior to balancing work as specified in the other sections of this specification.
- B. This Section includes testing, adjusting and balancing to produce design objectives for the following:
 - 1. Air Systems:
 - a. Constant-volume air systems.
 - b. Variable-air-volume systems.
 - 2. Hydronic Piping Systems:
 - a. Chilled water systems.
 - b. Hot water heating systems.
 - c. Dual temperature water systems.
 - 3. HVAC equipment quantitative-performance settings.
 - 3. Verifying that automatic control devices are functioning properly.
 - 4. Reporting results of activities and procedures specified in this Section.
 - 5. In general, the Balancing Work will occur at the end of the last phase of this project.

1.2 DEFINITIONS

- A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.
- B. Balance: To proportion flows within the distribution system, including sub-mains, branches, and terminals, according to indicated quantities.
- C. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.
- D. Draft: A current of air, when referring to localized effect caused by one or more factors

of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

- E. NC: Noise criteria.
- F. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.
- G. RC: Room criteria.
- H. Report Forms: Test data sheets for recording test data in logical order.
- I. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.
- J. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.
- K. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
- L. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.
- M. TAB: Testing, adjusting, and balancing.
- N. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.
- O. Test: A procedure to determine quantitative performance of systems or equipment.
- P. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.3 SUBMITTALS

- A. Qualification Data: Within 30 days from Contractor's Notice to Proceed, submit two (2) copies of evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Contract Documents Examination Report: Within 30 days from Contractor's Notice to Proceed, submit two (2) copies of the Contract Documents review report as specified in Part 3.
- C. Strategies and Procedures Plan: Within 90 days from Contractor's Notice to Proceed, submit two (2) copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.
- D. Certified TAB Reports: Submit two (2) copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.
- E. Sample Report Forms: Submit two (2) sets of sample TAB report forms.

- F. Warranties specified in this Section.

1.4 QUALITY ASSURANCE

- A. TAB Firm Qualifications: Engage a TAB firm certified by either AABC or NEBB.
- B. TAB Conference: Meet with Owner's and Architect's representatives on approval of TAB strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of TAB team members, equipment manufacturers' authorized service representatives, HVAC controls installers, and other support personnel. Provide seven (7) days' advance notice of scheduled meeting time and location.
 - 1. Agenda Items: Include at least the following:
 - a. Submittal distribution requirements.
 - b. The Contract Documents examination report.
 - c. TAB plan.
 - d. Work schedule and Project-site access requirements.
 - e. Coordination and cooperation of trades and subcontractors.
 - f. Coordination of documentation and communication flow.
- C. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:
 - 1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
 - 2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.
- D. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems", NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems", SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing", or TAB firm's forms approved by Engineer.
- E. Instrumentation Type, Quantity, and Accuracy: As described in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification."
- F. Instrumentation Calibration: Calibrate instruments at least every six (6) months or more frequently if required by instrument manufacturer.
 - 1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

1.5 PROJECT CONDITIONS

- A. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.6 COORDINATION

- A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.
- B. Notice: Provide seven (7) days' advance notice for each test. Include scheduled test dates and times.
- C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.7 WARRANTY

- A. National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents or provide a guarantee on NEBB forms stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee shall include the following provisions:
 - 1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
 - 2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 - PRODUCTS - NOT APPLICABLE

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
 - 1. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- B. Examine approved submittal data of HVAC systems and equipment.
- C. Examine Project Record Documents described in Division 1 Section "Project Record Documents."
- D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that

can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

- F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.
- G. Examine system and equipment test reports.
- H. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.
- I. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- J. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.
- K. Examine plenum ceilings used for supply air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.
- L. Examine strainers for clean screens and proper perforations.
- M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- N. Examine system pumps to ensure absence of entrained air in the suction piping.
- O. Examine equipment for installation and for properly operating safety interlocks and controls.
- P. Examine automatic temperature system components to verify the following:
 - 1. Dampers, valves, and other controlled devices are operated by the intended controller.
 - 2. Dampers and valves are in the position indicated by the controller.
 - 3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in variable-air-volume terminals.
 - 4. Automatic modulating and shutoff valves, including two-way valves, are properly connected.
 - 5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
 - 6. Sensors are located to sense only the intended conditions.
 - 7. Sequence of operation for control modes is according to the Contract Documents.
 - 8. Controller set points are set at indicated values.
 - 9. Interlocked systems are operating.

10. Changeover from heating to cooling mode occurs according to indicated values.

- Q. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

- A. Prepare a TAB plan that includes strategies and step-by-step procedures.
- B. Complete system readiness checks and prepare system readiness reports. Verify the following:
1. Permanent electrical power wiring is complete.
 2. Hydronic systems are filled, clean, and free of air.
 3. Automatic temperature control systems are operational.
 4. Equipment and duct access doors are securely closed.
 5. Balance and fire dampers are open.
 6. Isolating and balancing valves are open and control valves are operational.
 7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
 8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.
- C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross check the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.

- D. Determine the best locations in main and branch ducts for accurate duct airflow measurements.
- E. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling unit components.
- L. Check for proper sealing of air duct system.

3.5 PROCEDURES FOR CONSTANT VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 - 1. Measure fan static pressures to determine actual static pressure as follows:
 - a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
 - b. Measure static pressure directly at the fan outlet or through the flexible connection.
 - c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
 - d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
 - 2. Measure static pressure across each component that makes up a rooftop unit.
 - a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.
 - 3. Measure static pressures entering and leaving other devices such as sound traps and heat recovery equipment, under final balanced conditions.
 - 4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.
 - 5. Obtain approval from Engineer for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, belt, sheaves, motor sizes, and electrical connections to accommodate fan-speed changes including changing of belts, pulleys and sheaves.
 - 6. Do not make fan-speed adjustments that result in motor overload. Consult

equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in; full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.

- B. Adjust volume dampers for main duct, sub-main ducts, and major branch ducts to indicated airflows within specified tolerances.
 - 1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.
 - a. Where sufficient space in sub-main and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
 - 2. Re-measure each sub-main and branch duct after all have been adjusted. Continue to adjust sub-main and branch ducts to indicated airflows within specified tolerances.
- C. Measure terminal outlets and inlets without making adjustments.
 - 1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.
- D. Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.
 - 1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
 - 2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

- A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate.
- B. Prepare schematic diagrams of systems' "as-built" piping layouts.
- C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
 - 1. Open all manual valves for maximum flow.
 - 2. Check expansion tank liquid level.
 - 3. Check makeup-water station pressure gage for adequate pressure for highest vent.
 - 4. Check flow-control valves for specified sequence of operation and set at indicated flow.
 - 5. Set differential-pressure control valves at the specified differential pressure.
 - 6. Set system controls so automatic valves are wide open to heat exchangers.
 - 7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing

- device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.
 9. Check ethylene glycol percent by volume in chilled water system.

3.7 PROCEDURES FOR HYDRONIC SYSTEMS

- A. Measure water flow at pumps. Use the following procedures, except for positive-displacement pumps:
 1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
 3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
 4. Report flow rates that are not within plus or minus 5% of design.
- B. Verify flow rate through automatic flow control valves
- C. Measure flow at all stations and adjust, where necessary, to obtain first balance.
- D. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.
- E. Measuring the differential-pressure control valve settings existing at the conclusions of balancing.

3.8 PROCEDURES FOR MOTORS

- A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
 1. Manufacturer, model, and serial numbers.
 2. Motor horsepower rating.
 3. Motor rpm.
 4. Efficiency rating.
 5. Nameplate measured voltage and amperage for each phase.
 6. Starter thermal-protection-element rating.
- B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Record observations, including: controller manufacturer, model and serial numbers, and nameplate data.

3.9 PROCEDURES FOR HEAT TRANSFER COILS

- A. Water Coils: Measure the following data for each coil:

1. Entering and leaving water temperature.
2. Water flow rate.
3. Water pressure drop
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

B. Refrigerant Coils: Measure the following data for each coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.
5. Refrigerant suction pressure and temperature.

3.10 PROCEDURES FOR TEMPERATURE MEASUREMENTS

- A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.
- B. Measure indoor wet and dry bulb temperatures every other hour for a period of two (2) successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.
- C. Measure outside air, wet and dry-bulb temperatures.

3.11 TEMPERATURE-CONTROL VERIFICATION

- A. Verify that controllers are calibrated and commissioned.
- B. Check transmitter and controller locations and note conditions that would adversely affect control functions.
- C. Record controller settings and note variances between set points and actual measurements.
- D. Check the operation of limiting controllers (i.e., high and low temperature controllers).
- E. Check free travel and proper operation of control devices such as damper and valve operators.
- F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.
- G. Check the interaction of electrically operated switch transducers.
- H. Check the interaction of interlock and lockout systems.
- I. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or non-grounded power supply.

- J. Note operation of electric actuators using spring return for proper fail-safe operations.

3.12 TOLERANCES

- A. Set HVAC system airflow and water flow rates within the following tolerances:
 - 1. Supply, Return, and exhaust Fans and Equipment with Fans: Plus 5% to plus 10%.
 - 2. Air Outlets and Inlets: 0 to minus 10%.
 - 3. Heating-Water Flow Rate: 0 to minus 10%.
 - 4. Cooling-Water Flow Rate: 0 to minus 5%.

3.13 REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.
- B. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system.

3.14 FINAL REPORT

- A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.
- B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
 - 1. Include a list of instruments used for procedures, along with proof of calibration.
- C. Final Report Contents: In addition to certified field report data, include the following:
 - 1. Pump curves.
 - 2. Fan curves.
 - 3. Manufacturers' test data.
 - 4. Field test reports prepared by system and equipment installers.
 - 5. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

- D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:
1. Title page.
 2. Name and address of TAB firm.
 3. Project name.
 4. Project location.
 5. Architect's name and address.
 6. Engineer's name and address.
 7. Contractor's name and address.
 8. Report date.
 9. Signature of TAB firm who certifies the report.
 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 12. Nomenclature sheets for each item of equipment.
 13. Data for terminal units, including manufacturer, type size, and fittings.
 14. Notes to explain why certain final data in the body of reports varies from indicated values.
 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outside, return, and exhaust air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet and dry bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - f. Settings for supply air, static pressure controller.
 - g. Other system operating conditions that affect performance.
- E. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:
1. Unit Data: Include the following:
 - a. Unit identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.
 - h. Sheave make, size in inches, and bore.
 - i. Sheave dimensions, center-to-center, and amount of adjustments in inches.
 - j. Number of belts, make, and size.
 - k. Number of filters, type, and size.

2. Motor Data:
 - a. Make and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Sheave dimensions, center-to-center, and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Filter static pressure differential in inches wg.
 - f. Preheat coil static pressure differential in inches wg.
 - g. Cooling coil static pressure differential in inches wg.
 - h. Heating coil static pressure differential in inches wg.
 - i. Outside airflow in cfm.
 - j. Return airflow in cfm.
 - k. Outside air damper position.
 - l. Return air damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:
 - a. System identification.
 - b. Location.
 - c. Coil type.
 - d. Number of rows.
 - e. Fin spacing in fins per inch o.c.
 - f. Make and model number.
 - g. Face area in sq. ft.
 - h. Tube size in NPS.
 - i. Tube and fin materials.
 - j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Average face velocity in fpm.
 - c. Air pressure drop in inches wg.
 - d. Outside air, wet and dry bulb temperatures in deg F.
 - e. Return air, wet and dry bulb temperatures in deg F.
 - f. Entering air, wet and dry bulb temperatures in deg F.
 - g. Leaving air, wet and dry bulb temperatures in deg F.
 - h. Water flow rate in gpm.
 - i. Water pressure differential in feet of head or psig.
 - j. Entering water temperature in deg F.
 - k. Leaving water temperature in deg F.

- G. Fan Test Reports: For supply fans, include the following:
1. Fan Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and size.
 - e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in inches, and bore.
 - h. Sheave dimensions, center-to-center, and amount of adjustments in inches.
 2. Motor Data:
 - a. Make and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Sheave dimensions, center-to-center, and amount of adjustments in inches.
 - g. Number of belts, make, and size.
 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Suction static pressure in inches wg.
- H. Round and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
1. Report Data:
 - a. System and air-handling unit number.
 - b. Location and zone.
 - c. Duct static pressure in inches wg.
 - d. Duct size in inches.
 - e. Duct area in sq. ft.
 - f. Indicated airflow rate in cfm.
 - g. Indicated velocity in fpm.
 - h. Actual airflow rate in cfm.
 - i. Actual average velocity in fpm.
- I. Air-Terminal-Device Reports:
1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Test apparatus used.
 - d. Area served.

2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Air velocity in fpm.
 - c. Preliminary airflow rate as needed in cfm.
 - d. Preliminary velocity as needed in fpm.
 - e. Final airflow rate in cfm.
 - f. Final velocity in fpm.
 - g. Space temperature in deg F.

- J. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
 1. Unit Data:
 - a. System and air handling unit identification.
 - b. Location and zone.
 - c. Room or riser served.
 - d. Coil make and size.
 - e. Flowmeter type.

 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Entering water temperature in deg F.
 - c. Leaving water temperature in deg. F.
 - d. Water pressure drop in feet of head or psig.
 - e. Entering air temperature in deg F.
 - f. Leaving air temperature in deg F.

- K. Pump Test Reports:
 1. Unit Data:
 - a. Unit identification
 - b. Location.
 - c. Service.
 - d. Make and size.
 - e. Model and serial numbers.
 - f. Water flow rate in gpm.
 - g. Water pressure differential in feet of head or psig.
 - h. Required net positive suction head in feet of head or psig.
 - i. Pump rpm.
 - j. Impeller diameter in inches.
 - k. Motor make and frame size.
 - l. Motor horsepower and rpm.
 - m. Voltage at each connection.
 - n. Amperage for each phase.
 - o. Full load amperage and service factor.
 - p. Seal type.

 2. Test Data (Indicated and Actual Values):

- a. Static head in feet of head or psig.
- b. Pump shutoff pressure in feet of head or psig.
- c. Actual impeller size in inches.
- d. Full open flow rate in gpm.
- e. Full open pressure in feet of head or psig.
- f. Final discharge pressure in feet of head or psig.
- g. Final suction pressure in feet of head or psig.
- h. Final total pressure in feet of head or psig.
- i. Final water flow rate in gpm.
- j. Voltage at each connection.
- k. Amperage for each phase.

L. Air to Air Heat-Recovery Unit Reports:

1. Unit Data:

- a. Unit identification.
- b. Location.
- c. Service.
- d. Make and type.
- e. Model and serial numbers.

2. Test Data (Indicated and Actual Values):

- a. Total exhaust airflow rate in cfm.
- b. Outside airflow rate in cfm.
- c. Total exhaust fan static pressure in inches wg.
- d. Total outside air fan static pressure in inches wg.
- e. Pressure drop on each side of heat exchanger in inches wg.
- f. Exhaust air temperature humidity entering in deg F and % RH.
- g. Exhaust air temperature humidity leaving in deg F and % RH.
- h. Outside air temperature humidity entering in deg F and % RH.
- i. Outside air temperature humidity leaving in deg F and % RH.
- j. Calculate sensible and total heat capacity of each airstream in MBh

M. Combustion Test:

1. Unit Data

- a. Boiler manufacturer.
- b. Model number.
- c. Serial number.
- d. Firing rate.
- e. Overfire draft
- f. Gas meter timing dial size.
- g. Gas meter time per revolution.
- h. Gas pressure at meter outlet.
- i. Gas flow rate.
- j. Heat input.
- k. Burner manifold gas pressure.
- l. Percent carbon monoxide (CO).
- m. Percent carbon dioxide (CO₂).
- n. Percent oxygen (O₂).
- o. Percent excess air.

- p. Flue gas temperature at outlet.
- q. Ambient temperature.
- r. Net stack temperature.
- s. Percent stack loss.
- t. Percent combustion efficiency.
- u. Heat output.

N. Air Cooled Condenser:

1. Unit Data

- a. Identification/number.
- b. Location.
- c. Manufacturer.
- d. Model number.
- e. Serial number.
- f. Entering DB air temperature, design and actual.
- g. Leaving DB air temperature, design and actual.
- h. Number of compressors.

O. Instrument Calibration Reports:

1. Report Data:

- a. Instrument type and make.
- b. Serial number.
- c. Application.
- d. Dates of use.
- e. Dates of calibration.

3.15 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.
2. Randomly check the following for each system:
 - a. Measure airflow of at least 10% of air outlets.
 - b. Measure water flow of at least 5% of terminals.
 - c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
 - d. Verify that balancing devices are marked with final balance position.
 - e. Note deviations to the Contract Documents in the Final Report.

B. Final Inspection:

1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Architect.

2. TAB firm test and balance engineer shall conduct the inspection in the presence of Architect.
3. Architect shall randomly select measurements documented in the final report to be rechecked. The rechecking shall be limited to either 10% of the total measurements recorded, or the extent of measurements that can be accomplished in a normal 8 hour business day.
4. If the rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
5. If the number of "FAILED" measurements is greater than 10% of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report.
7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

3.16 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.

END OF SECTION 230593

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SECTION 230700 - PIPE INSULATION

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes preformed, rigid and flexible pipe insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.

1.2 SUBMITTALS

- A. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.
- B. Shop Drawings: Show fabrication and installation details for the following:
 - 1. Application of protective shields, saddles, and inserts at pipe hangers for each type of insulation and hanger.
 - 2. Insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 3. Removable insulation at piping specialties and equipment connections.
 - 4. Application of field-applied jackets.

1.3 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the U.S. Department of Labor, Bureau of Apprenticeship and Training.
- B. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.
 - 1. Insulation Installed Indoors: Flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.
- C. ASHRAE Standards: Comply with performance efficiencies prescribed for ASHRAE 90.1, "Energy Efficient Design for New Buildings, Except Low Rise Residential Buildings" for pipe insulation.
- D. No damaged or water soaked insulation shall be used.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.5 COORDINATION

- A. Coordinate size and location of supports, hangers, and insulation shields.
- B. Coordinate clearance requirements with piping installer for insulation application.

1.6 SCHEDULING

- A. Schedule insulation application after testing piping systems. Insulation application may begin on segments of piping that have satisfactory test results.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified.
 - 1. Mineral-Fiber Insulation:
 - a. CertainTeed Manson.
 - b. Knauf FiberGlass GmbH.
 - c. Owens-Corning Fiberglas Corp.
 - d. Schuller International, Inc.
 - e. Armacell

2.2 INSULATION MATERIALS

- A. Mineral-Fiber Insulation: Glass fibers bonded with a thermosetting resin complying with the following:
 - 1. Preformed Pipe Insulation: Comply with ASTM C 547, Type 1, with factory-applied, all-purpose, vapor-retarder jacket.
 - 2. Fire-Resistant Adhesive: Comply with MIL-A-3316C in the following classes and grades:
 - a. Class 1, Grade A for bonding glass cloth and tape to unfaced glass-fiber insulation, for sealing edges of glass-fiber insulation, and for bonding lagging cloth to unfaced glass-fiber insulation.
 - b. Class 2, Grade A for bonding glass-fiber insulation to metal surfaces.
 - 3. Vapor-Retarder Mastics: Fire- and water-resistant, vapor-retarder mastic for indoor applications. Comply with MIL-C-19565C, Type II.
 - 4. Mineral-Fiber Insulating Cements: Comply with ASTM C 195.
 - 5. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.
- B. Cellular-Glass Insulation: Foamed glass, annealed, rigid, hermetically sealed cells, incombustible. Preformed Pipe Insulation, with Jacket: Comply with ASTM C 552, Type II, Class 2.

- C. Flexible Elastomeric Thermal Insulation: Closed-cell, sponge- or expanded-ruber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
 - 1. Adhesive: As recommended by insulation material manufacturer.
- D. Prefabricated Thermal Insulating Fitting Covers: Comply with ASTM C 450 for dimensions used in preforming insulation to cover valves.

2.3 FIELD APPLIED JACKETS

- A. General: ASTM C 921, Type 1, unless otherwise indicated.
- B. Standard PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 20-mil thick, high-impact, ultraviolet-resistant PVC.
 - 1. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, reducers, end caps, soil-pipe hubs, traps and mechanical joints.
 - 2. Adhesive: As recommended by insulation material manufacturer.
- C. PVC Jacket: High-impact-resistant, UV resistant PVC complying with ASTM D1784, Class 16354-C; 30 mils thick; roll stock ready for shop or field cutting and forming. Finish color to be white.
- D. Aluminum Jacket: Aluminum roll stock, ready for shop or field cutting and forming to indicated sizes. Comply with ASTM B 209, 3003 alloy, H-14 temper
 - 1. Finish and Thickness: Stucco-embossed finish, 0.020-inch thick.
 - 2. Moisture Barrier: 1-mil thick, heat-bonded polyethylene and kraft paper.
 - 3. Elbows: Preformed, 45- and 90-degree, short- and long-radius elbows; same material, finish, and thickness as jacket.
- E. Glass Cloth Covering: Self-adhesive, mastic impregnated, rewettable cloth.
 - 1. Thickness: 0.028 inches
 - 2. Maximum Service Temperature: 450 degrees F.
 - 3. Density: 14.3 oz/sq yd
 - 4. Surface Burning Characteristic: 25/50 per ASTM E84

2.4 ACCESSORIES AND ATTACHMENTS

- A. Bands: 3/4 inch wide, in one of the following materials compatible with jacket:
 - 1. Aluminum: 0.007 inch thick.
- B. Wire: 0.080 inch, nickel-copper alloy; 0.062 inch, soft-annealed, stainless steel; or 0.062 inch soft-annealed, galvanized steel.
- C. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for cloth and Type II for tape. Woven glass-fiber fabrics, plain weave presized a minimum of 14.3 oz./sq. yd.
 - 1. Tape Width: 4 inches.

2.5 VAPOR RETARDERS

- A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

PART 3 – EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry pipe and fitting surfaces. Remove materials that will adversely affect insulation application.

3.3 GENERAL APPLICATION REQUIREMENTS

- A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.
- B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each piping system.
- C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Apply insulation with longitudinal seams at top and bottom of horizontal pipe runs.
- E. Apply multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.
- H. Keep insulation materials dry during application and finishing.
- I. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.
- J. Apply insulation with the least number of joints practical.
- K. Apply insulation over fittings, valves, and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated. Refer to special instructions for applying insulation over fittings, valves, and specialties.

- L. Hangers and Anchors:
 - 1. Apply insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor retarders are indicated, extend insulation on anchor legs at least 12 inches from point of attachment to pipe and taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.
 - 3. Install insert materials and apply insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by the insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect the jacket from tear or puncture by the hanger, support, and shield.

- M. Insulation Terminations: For insulation application where vapor retarders are indicated, taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

- N. Apply adhesives and mastics at the manufacturer's recommended coverage rate.

- O. Apply insulation with integral jackets as follows:
 - 1. Pull jacket tight and smooth.
 - 2. Circumferential Joints: Cover with 3-inch wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip and spaced 4 inches o.c.
 - 3. Longitudinal Seams: Overlap jacket seams at least 1-1/2 inches. Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.
 - a. Exception: Do not staple longitudinal laps on insulation having a vapor retarder.
 - 4. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to flanges, unions, valves, and fittings.
 - 5. At penetrations in jackets for thermometers and pressure gages, fill and seal voids with vapor-retarder mastic.

- P. Exterior Wall Penetrations: For penetrations of below-grade exterior walls, terminate insulation flush with mechanical sleeve seal. Seal terminations with vapor-retarder mastic.

- Q. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and floors.

- R. Fire-Rated Wall and Partition Penetrations: Apply insulation continuously through penetrations of fire-rated walls and partitions.
 - 1. Firestopping and fire-resistive joint sealers are specified in Division 7 Section "Firestopping."

- S. Floor Penetrations: Apply insulation continuously through floor assembly.

1. For insulation with vapor retarders, seal insulation with vapor-retarder mastic where floor supports penetrate vapor retarder.

3.4 MINERAL-FIBER INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure each layer of preformed pipe insulation to pipe with wire, tape, or bands without deforming insulation materials.
2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic. Apply vapor retarder to ends of insulation at intervals of 15 to 20 feet to form a vapor retarder between pipe insulation segments.
3. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6 inches on center.
4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.
5. All exposed ends for mineral fiber insulation shall be neatly trimmed and beveled. All exposed insulation material shall be covered with mastic.

B. Apply insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Apply canvas jacket material with manufacturer's recommended adhesive, overlapping seams at least 1 inch, and seal joints with vapor-retarder mastic.

C. Apply insulation to fittings and elbows as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions and cover with insulating cement trowelled smooth.
2. When premolded insulation elbows and fittings are not available, apply mitered sections of pipe insulation, or glass-fiber blanket insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with tape and cover with insulating cement trowelled smooth.
3. Cover fittings with standard PVC fitting covers.

D. Apply insulation to valves and specialties as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When premolded insulation sections are not available, apply glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to strainer basket without disturbing insulation.

3.5 CELLULAR GLASS INSULATION APPLICATION

- A. Apply insulation to straight pipes and tubes as follows:
 - 1. Secure each layer of insulation to pipe with wire, tape, or bands without deforming insulation materials.
 - 2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic.
 - 3. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6 inches o.c.
 - 4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.
 - 5. All exposed ends for mineral fiber insulation shall be neatly trimmed and beveled. All exposed insulation material shall be covered with mastic.

3.6 FIELD APPLIED JACKET APPLICATION

- A. Apply aluminum metal jacket for all exterior above ground chilled water piping, with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal joints with weatherproof sealant recommended by insulation cover manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.
- B. Apply glass cloth or PVC jacket, for piping that is exposed in all areas including mechanical rooms, directly over insulation with factory-applied jackets.
 - 1. Apply jacket smooth and tight to surface with 1-inch overlap at seams and joints.
 - 2. Embed glass cloth between two (2) 0.062-inch thick coats of jacket manufacturer's recommended adhesive.
 - 3. Completely encapsulate insulation with jacket, leaving no exposed raw insulation.
- C. Provide PVC fitting covers for all exposed piping that is to be insulated. For Victaulic piping, provide PVC fitting covers for all fittings and couplings.

3.7 PIPING SYSTEM APPLICATIONS

- A. Materials and thicknesses for systems listed below are specified in schedules within this section.
- B. Insulate the following piping systems:
 - 1. Insulate heating hot water supply and return piping with glass fiber insulation
 - 2. Insulate indoor chilled water supply and return piping with glass fiber insulation.
 - 3. Insulate outdoor chilled water supply and return piping with closed cell elastomeric insulation.
 - 4. Make up mechanical city water piping with glass fiber insulation.
- C. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:
 - 1. Flexible connectors.
 - 2. Vibration-control devices.
 - 3. Fire-suppression piping.

4. Below-grade piping, unless otherwise indicated.
5. Chrome-plated pipes and fittings, unless potential for personnel injury.
6. Hot water air chambers, unions, strainers, check valves, plug valves, and flow regulators.

D. MINIMUM INSULATION THICKNESS FOR PIPE SIZES

Hot water, chilled water and dual temperature water piping insulation shall be 1-1/2" thick.

PIPING SYSTEM TYPES	FLUID TEMPERATURE RANGES (DEG. F)	LESS THAN 1" (INCHES)	1" TO 1-1/4" (INCHES)	1-1/2" TO 3" (INCHES)	4" AND LARGER (INCHES)
Make-up Water	40°-55°F	0.5	0.5	1.0	1.0

NOTE: The minimum listed thickness is based on a minimum R value of 4.6. Thickness to vary if the insulation R value is different than 4.6. In addition, the minimum thickness is to be increased as required to meet ASHRAE 90.1.

- E. Insulation at fire walls: All insulated piping penetrating walls with a fire resistive rating shall be insulated with molded foam glass; AASJ-SSL@ covering with a dual purpose fireproof, kraft aluminum foil, laminated white jacket. Insulation to be of same thickness as adjoining insulation.

F. SUCTION REFRIGERANT AND CONDENSATE DRAIN PIPING

1. Pipe Insulation: 3/4 inch thick, fire retardant, flexible elastomeric thermal insulation.
2. Exposed Exterior Insulation: Cover with two coats of the insulation manufacturer's coating that is recommended for UV protection.

G. PIPE INSULATING SUPPORT

1. On insulated piping with pipe supports around outside of covering provide galvanized steel formed bearing plates. Plates to be lined with length of foam glass insulation.
 - a. 8" and smaller pipe: 12" long, 12 gauge plate
 - b. 10" and larger pipe: 24" long, 10 gauge plate

3.8 FIELD QUALITY CONTROL

- A. Insulation applications will be considered defective if sample inspection reveals noncompliance with requirements. Remove defective Work and replace with new materials according to these Specifications.

END OF SECTION 230700

SECTION 230701 - EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes blanket insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.

1.2 SUBMITTALS

- A. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.
- B. Shop Drawings: Show fabrication and installation details for the following:
 - 1. Field application for each equipment type.
 - 2. Removable insulation sections at access panels.
 - 3. Application of field-applied jackets.
 - 4. Special shapes for cellular-glass insulation.

1.3 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the U.S. Department of Labor, Bureau of Apprenticeship and Training.
- B. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.
 - 1. Insulation Installed Indoors: Flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.5 COORDINATION

- A. Coordinate clearance requirements with equipment installer for insulation.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Flexible Elastomeric Thermal Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type II for sheet materials.
 - 1. Adhesive: As recommended by insulation material manufacturer.

2.2 FIELD APPLIED JACKETS

- A. General: ASTM C 921, Type 1, unless otherwise indicated.
- B. Glass Cloth Covering: Self-adhesive, mastic impregnated, rewettable cloth.
 - 1. Thickness: 0.028 inches
 - 2. Maximum Service Temperature: 450 degrees F.
 - 3. Density: 14.3 oz/sq yd
 - 4. Surface Burning Characteristic: 25/50 per ASTM E84

2.2 ACCESSORIES AND ATTACHMENTS

- A. Bands: 3/4 inch wide, in one of the following materials compatible with jacket:
 - 1. Aluminum: 0.007 inch thick.
- B. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for Cloth and Type II for Tape. Woven glass-fiber fabrics, plain weave presized a minimum of 14.3 oz/sq. yd.
 - 1. Tape width: 4 inches

PART 3 – EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL APPLICATION REQUIREMENTS

- A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of equipment.
- B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each equipment system.
- C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either the wet or dry state.
- D. Apply multiple layers of insulation with longitudinal and end seams staggered.
- E. Keep insulation materials dry during application and finishing.
- F. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.
- G. Apply insulation with the least number of joints practical.
- H. Apply insulation over fittings and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
- I. Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.

3.4 EQUIPMENT APPLICATIONS

- A. Materials and thicknesses for equipment listed below are specified in this Section.
- B. Insulate the following indoor equipment:
 - 1. Dual Temperature water pump housings.
 - 2. Strainers.
- C. Omit insulation from the following hot water system and provide removable insulation segments for chilled water system:
 - 1. Vibration-control devices.
 - 2. Testing agency labels and stamps.
 - 3. Nameplates and data plates.

D. Equipment Insulation Type:

1. Operating Temperature: 20 to 70 deg. F.
2. Insulation Material: Flexible Elastomeric.
3. Insulation Thickness: 1 inch.

3.5 FIELD QUALITY CONTROL

- A. Insulation applications will be considered defective if sample inspection reveals noncompliance with requirements. Remove defective Work and replace with new materials according to these Specifications.

END OF SECTION 230701

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SECTION 230702 - DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes semi-rigid and flexible duct and plenum insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.

1.2 SUBMITTALS

- A. Product Data: Identify thermal conductivity, thickness and jackets (both factory and field applied, if any), for each type of product indicated.
- B. Shop Drawings: Show fabrication and installation details for the following:
 - 1. Removable insulation sections at access panels.
 - 2. Application of field-applied jackets.
 - 3. Applications at linkages for control devices.

1.3 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the U.S. Department of Labor, Bureau of Apprenticeship and Training.
- B. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.
 - 1. Insulation Installed Indoors: Flame-spread rating of 25 or less and smoke-developed rating of 50 or less.
- C. ASHRAE Standards: Comply with performance efficiencies prescribed for ASHRAE 90.1, "Energy Efficient Design for New Buildings, Except Low Rise Residential Buildings" for duct insulation.
- D. No damaged or water soaked insulation shall be used.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade and maximum use temperature.

1.5 COORDINATION

- A. Coordinate clearance requirements with duct Installer for insulation application.

1.6 SCHEDULING

- A. Schedule insulation application after testing duct systems. Insulation application may begin on segments of ducts that have satisfactory test results.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified:
 - 1. Mineral-Fiber Insulation:
 - a. CertainTeed Manson.
 - b. Knauf FiberGlass GmbH.
 - c. Owens-Corning Fiberglas Corp.
 - d. Schuller International, Inc.
 - e. Aeroflex USA Inc.; Aerocel.
 - f. Armacell LLC; AP Armaflex.
 - g. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

2.2 INSULATION MATERIALS

- A. Mineral-Fiber Board Thermal Insulation: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IB, without facing and with all-service jacket manufactured from aluminum foil, skim kraft, vapor seal.
- B. Mineral-Fiber Blanket Thermal Insulation: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II, without facing and with all-service jacket manufactured from aluminum foil, skim kraft, vapor seal.
- C. Glass Fiber Duct Liner
 - 1. Insulation ASTM C553; flexible noncombustible with erosion resistant and mold resistant coating.
 - a. 'K' value: ASTM C518 and C177, 024 at 75 degrees F.
 - b. Maximum Service Temperature: 250 degrees F.
 - c. Maximum Moisture Absorption: 0.5 percent per volume.
 - d. Density: 3.0 1l/cu ft.
- D. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

2.3 FIELD-APPLIED JACKETS

- A. General: ASTM C 921, Type 1, unless otherwise indicated.
- B. Foil and Paper Jacket: Laminated, glass-fiber-reinforced, flame-retardant kraft paper and aluminum foil.

- C. Glass Cloth Covering: Self-adhesive, mastic impregnated, rewettable cloth.
 - 1. Thickness: 0.028 inches
 - 2. Maximum Service Temperature: 450 degrees F.
 - 3. Density: 14.3 pz/sq yd
 - 4. Surface Burning Characteristic: 25/50 per ASTM E84

- D. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.
 - 2. Sheet and roll stock ready for shop or field sizing.
 - 3. Finish and thickness are indicated in field-applied jacket schedules.
 - 4. Factory-Fabricated Fitting Covers:
 - a. Same material, finish, and thickness as jacket.
 - b. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - c. Tee covers.
 - d. Flange and union covers.
 - e. End caps.
 - f. Beveled collars.
 - g. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.4 ACCESSORIES AND ATTACHMENTS

- A. Wire: 0.062-inch, soft-annealed, galvanized steel.

- B. Adhesive-Attached Anchor Pins and Speed Washers: Galvanized steel plate, pin and washer manufactured for attachment to duct and plenum with adhesive. Pin length sufficient for insulation thickness indicated.
 - 1. Adhesive: Recommended by the anchor pin manufacturer as appropriate for surface temperatures of ducts and plenums; and to achieve a holding capacity of 100 lb for direct pull perpendicular to the adhered surface.

- C. Self-Adhesive Anchor Pins and Speed Washers: Galvanized steel plate, pin, and washer manufactured for attachment to duct and plenum with adhesive. Pin length sufficient for insulation thickness indicated.

- D. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for cloth and Type II for tape. Woven glass-fiber fabrics, plain weave, presized a minimum of 14.3 oz./sq. yd.
 - 1. Tape Width: 4 inches

- E. Aluminum Jacket strapping and seals: All jacketing shall be secured on not greater than 18 inch centers with aluminum straps not less than 0.20 inch thickness. All jacketing shall have 0.75 inch wide aluminum wing seals not less than 0.32 inch thickness.

2.5 VAPOR RETARDERS

- A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets and substrates.

PART 3 – EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL APPLICATION REQUIREMENTS

- A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of ducts and fittings.
- B. Refer to schedules at the end of this Section for materials, forms, jackets and thicknesses required for each duct system.
- C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften or otherwise attack insulation or jacket in either wet or dry state.
- D. Apply multiple layers of insulation with longitudinal and end seams staggered.
- E. Keep insulation materials dry during application and finishing.
- F. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.
- G. Apply insulation with the least number of joints practical.
- H. Apply insulation over fittings and specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
- I. Apply insulation with integral jackets as follows:
 - 1. Pull jacket tight and smooth.
 - 2. Joints and Seams: Cover with tape and vapor retarder as recommended by insulation material manufacturer to maintain vapor seal.
- J. Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.
- K. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions.
- L. Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations.

- M. Provide weld pins located a maximum of 18 inches on center for all insulation serving ductwork that has a width or height dimension that exceeds 20 inches.
- N. Floor Penetrations: Terminate insulation at underside of floor assembly and at floor support at top of floor.
 - 1. For insulation indicated to have vapor retarders, taper termination and seal insulation ends with vapor-retarder mastic.

3.4 MINERAL FIBER INSULATION APPLICATION

- A. Blanket or Board Applications for Ducts and Plenums: Secure blanket insulation with adhesive, anchor pins and speed washers.
 - 1. Apply adhesives according to manufacturer's recommended coverage rates per square foot for 100 percent coverage of duct and plenum surfaces.
 - 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 - 3. Install anchor pins and speed washers on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints and locate 16 inches on center.
 - b. On duct sides with dimensions larger than 18 inches. Space 16 inches on center each way and 3 inches maximum from insulation joints. Apply additional pins and clips to hold insulation tightly against surface at cross bracing.
 - c. Anchor pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not over-compress insulation during installation.
 - 4. Impale insulation over anchors and attach speed washers.
 - 5. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 - 6. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation segment with 1/2-inch staples, 1 inch on center and cover with pressure-sensitive tape having same facing as insulation.
 - 7. Apply insulation on rectangular duct elbows and transitions with a full insulation segment for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Apply insulation on round duct elbows with individually mitered gores cut to fit the elbow.
 - 8. Insulate duct stiffeners, hangers and flanges that protrude beyond the insulation surface with 6-inch wide strips of the same material used to insulate duct. Secure on alternating sides of stiffener, hanger and flange with anchor pins spaced 6 inches on center.

3.5 FIELD APPLIED JACKET APPLICATION

- A. Apply glass cloth jacket directly over insulation with factory applied jackets for all exposed insulation for all exposed insulation in finished, occupied rooms, including Lobby 100B, Reading Room Circulation 131, Student Dining 167 and Scene Shop 149.

1. Apply jacket smooth and tight to surface with 2-inch overlap at seams and joints.
 2. Embed glass cloth between two (2) 0.062-inch thick coats of jacket manufacturer=s recommended adhesive.
 3. Completely encapsulate insulation with jacket, leaving no exposed raw insulation.
- B. Apply aluminum jacket directly over flexible elastomeric insulation located exterior to the building.
1. Apply aluminum jacket as recommended by the manufacture.
 2. Completely encapsulate insulation with jacket leaving no exposed raw insulation.
 3. Seal watertight.

3.6 DUCT SYSTEM APPLICATIONS

- A. Materials and thicknesses for systems listed below are specified in schedules at the end of this Section.
- B. Insulate the following plenums and duct systems:
1. Indoor concealed supply, return and outside air ductwork.
 2. Indoor exposed supply, return and outside air ductwork.
 3. Indoor outside air plenums connected to louvers.
 4. Indoor exhaust air ductwork and plenums from exhaust louver or discharge hood to the discharge of the exhaust fan or air handling unit.
 5. Indoor exhaust air ductwork located within 10 feet of roof mounted exhaust fan with backdraft damper.
- C. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials and equipment:
1. Metal ducts with duct liner.
 2. Manufactured double wall, insulated duct systems.
 3. Factory-insulated flexible ducts.
 4. Factory-insulated plenums, casings, terminal boxes, filter boxes and sections.
 5. Flexible connectors.
 6. Vibration-control devices.
 7. Testing agency labels and stamps.
 8. Nameplates and data plates.
 9. Access panels and doors in air-distribution systems.

3.7 INDOOR DUCT AND PLENUM APPLICATION SCHEDULE

- A. Service: Round supply, return, exhaust and outdoor air ducts; concealed.
1. Material: Mineral-fiber blanket.
 2. Thickness: 1-1/2 inches.
 3. Minimum R value: 3.5.
 4. Number of Layers: One.
- B. Service: Rectangular supply, return, exhaust and outdoor air ducts; concealed.
1. Material: Mineral-fiber blanket.
 2. Thickness: 1-1/2 inches.
 3. Minimum R value: 3.5.

4. Number of Layers: One.
- C. Service: Round supply, return, exhaust and outdoor air ducts; exposed.
1. Material: Mineral-fiber board.
 2. Thickness: 1-1/2 inches.
 3. Minimum R Value: 3.5.
 4. Number of Layers: One.
- D. Service: Rectangular supply, return, exhaust and outdoor air ducts; exposed.
1. Material: Mineral-fiber board.
 2. Thickness: 1-1/2 inches.
 3. Minimum R Value: 3.5.
 4. Number of Layers: One.
- E. Service: Rectangular transfer air ducts.
1. Material: Fiberglass Duct Liner
 2. Thickness: 1 inch
- F. Service: Rectangular and round supply and return air ducts in spaces not tempered.
1. Insulation Material: Mineral fiber blanket.
 2. Thickness: 2 inches.
 3. Minimum R Value: 8

END OF SECTION 230702

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SECTION 230800 – COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.
- B. Refer to Section 019113 "Commissioning" for all specific requirements required associated with the commissioning process that will be required as part of this work. As part of this project, participation in the commissioning process as described in Section 01 91 13 shall be required.

1.2 SUMMARY

- A. Section includes commissioning process requirements for HVAC systems, assemblies, and equipment.
- B. Related Sections:
 - 1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 DEFINITIONS

- A. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.
- B. CxA: Commissioning Authority.
- C. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.
- D. DDC: Direct Digital Controls.
- E. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.4 ALLOWANCES

- A. Labor, instrumentation, tools, and equipment costs for technicians for the performance of commissioning testing are covered by the "Schedule of Allowances" Article in Division 01 Section "Allowances."

1.5 UNIT PRICES

- A. Commissioning testing allowance may be adjusted up or down by the "List of Unit Prices" Article in Division 01 Section "Unit Prices" when actual man-hours are computed at the end of commissioning testing.

1.6 CONTRACTOR'S RESPONSIBILITIES

- A. Perform commissioning tests at the direction of the CxA.
- B. Attend construction phase HVAC and Integrated Automation coordination meetings.
- C. Attend testing, adjusting, and balancing review and coordination meetings.
- D. Participate in HVAC systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
- E. Provide information requested by the CxA for final commissioning documentation.
- F. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.7 CxA'S RESPONSIBILITIES

- A. Provide Project-specific construction checklists and commissioning process test procedures for actual HVAC systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.
- B. Direct commissioning testing.
- C. Verify testing, adjusting, and balancing of Work are complete.
- D. Provide test data, inspection reports, and certificates in Systems Manual.

1.8 COMMISSIONING DOCUMENTATION

- A. Provide the following information to the CxA for inclusion in the commissioning plan:
 - 1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
 - 2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
 - 3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVAC systems, assemblies, equipment, and components to be verified and tested.
 - 4. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.
 - 5. Certificate of readiness certifying that HVAC systems, subsystems, equipment, and associated controls are ready for testing.

6. Test and inspection reports and certificates.
7. Corrective action documents.
8. Verification of testing, adjusting, and balancing reports.

1.9 SUBMITTALS

- A. Certificates of readiness.
- B. Certificates of completion of installation, prestart, and startup activities.

1.10 COMMISSIONING AUTHORITY

- A. Motz Engineering acting in conjunction with the Owner's Maintenance Personnel will take the role of the Commissioning Authority for this project. The Commissioning Authority will respond to all issues directly to the Owner and shall have the authority to grant final acceptance of each system commissioned.

1.11 COMMISSIONING PLAN

- A. This section and sections in other Divisions shall outline the work required for the project, consistent with the Commissioning Plan. Any discrepancies between the Commissioning Plan and the Project Manual sections shall be brought to the attention of the Commissioning Agent for clarification.

1.12 COORDINATION

- A. The HVAC Contractor and appropriate Subcontractors shall be responsible for cooperating and coordinating their work during the installation and commissioning process. Refer to the specific requirements and other sections for required work associated with coordination of installation work and preparation of Coordination Construction Drawings by the contractors.
- B. The Commissioning Authority will participate in the coordination of installation work as necessary to insure the installation of system components meet the Owner's project requirements and will provide a facility that has appropriate access and means for future maintenance and service by Owner.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

- A. Certify that HVAC systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

- B. Certify that HVAC instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.
- C. Certify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- E. Inspect and verify the position of each device and interlock identified on checklists.
- F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
- G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.2 TESTING VERIFICATION

- A. Prior to performance of testing and balancing Work, provide copies of reports, sample forms, checklists, and certificates to the CxA.
- B. Notify the CxA at least 10 days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.
- C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC systems at the direction of the CxA.
 - 1. The CxA will notify testing and balancing Subcontractor 10 days in advance of the date of field verification. Notice will not include data points to be verified.
 - 2. The testing and balancing Subcontractor shall use the same instruments (by model and serial number) that were used when original data were collected.
 - 3. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.
 - 4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.3 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- B. Scope of HVAC testing shall include entire HVAC installation.

- C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.
- D. Tests will be performed using design conditions whenever possible.
- E. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
- F. The CxA may direct that set points be altered when simulating conditions is not practical.
- G. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.
- H. If tests cannot be completed because of a deficiency outside the scope of the HVAC system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.
- I. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.4 HVAC SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. The following systems shall be commissioned:
 - 1. HVAC systems including:
 - a. Direct digital automatic temperature control system.
 - b. Air distribution systems.
 - c. Exhaust systems.
 - d. Unitary equipment.

END OF SECTION 230800

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SECTION 232111 - PIPING MATERIALS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes a summary of all Piping Materials related work:
- B. Related Sections:
 - 1. 23 21 13 – HYDRONIC PIPING

1.3 HOT WATER PIPING

- A. 2 ½" and Larger.
 - 1. Pipe: Standard, A-53 black steel.
 - 2. Fittings: Standard, butt-weld.
- B. 2" and Smaller.
 - 1. Pipe: Type "L" copper tubing, hard temper.
 - 2. Fittings: Solder end, cast red brass or wrought copper.

1.4 CHILLED WATER PIPING

- A. 2-1/2" and Larger.
 - 1. Pipe: Standard, A-53 black steel.
 - 2. Fittings: Standard, butt-weld.
- B. 2" and Smaller.
 - 1. Pipe: Type "L" copper tubing, hard temper.
 - 2. Fittings: Solder end, cast red brass or wrought copper.

1.5 DUAL TEMPERATURE WATER PIPING

- A. 2-1/2" and Larger.
 - 1. Pipe: Standard, A-53 black steel.
 - 2. Fittings: Standard, butt-weld.
- B. 2" and Smaller.
 - 1. Pipe: Type "L" copper tubing, hard temper.
 - 2. Fittings: Solder end, cast red brass or wrought copper.

1.6 MECHANICAL CITY WATER

- A. 3" and Smaller
 - 1. Pipe: Hard Temper, Type "L" copper, with solder joints.
 - 2. Fittings: Wrought copper with solder joints.

1.7 DRAIN PIPING

- A. Copper Piping.
 - 1. Pipe: Type "L" copper tubing, hard temper.
 - 2. Fittings: Solder end, cast red brass or wrought copper.
- B. Steel Piping.
 - 1. Pipe: Standard, A-53 black steel.
 - 2. Fittings: Threaded 150# black malleable iron or 125# black cast iron.
 - 3.

PART 2 – PRODUCTS – (NOT USED)

PART 3 – EXECUTION – (NOT USED)

END OF SECTION 232111

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SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes piping, special-duty valves, and hydronic specialties for air vent piping, blowdown drain lines and condensate drain piping.

1.2 SUBMITTALS

- A. Shop Drawings: Detail fabrication of pipe anchors, hangers, special pipe support assemblies, alignment guides, expansion joints and loops, and their attachment to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

- 1. Grooved joint couplings and fittings shall be shown on drawings and product submittals and shall be specifically identified with the applicable manufacturer's style or series designation.

- B. Welding Certificates: Copies of certificates for welding procedures and personnel.

- C. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:

- 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Failed test results and corrective action taken to achieve requirements.

- D. Maintenance Data: For hydronic specialties and special-duty valves to include in maintenance manuals specified in Division 1.

- E. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.3 QUALITY ASSURANCE

- A. Welding: Qualify processes and operators according to the ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

- B. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

- C. To assure uniformity and compatibility of piping products in grooved end piping systems, all groove products utilized shall be supplied by a single manufacturer. Grooving tools shall be supplied by the same manufacturer.

- D. The grooved coupling manufacturer's factory trained representative shall provide on-site training for contractor's field personnel in use of grooving tools, application of groove and installation of grooved joint products. The manufacturer's representative

shall periodically visit the jobsite and review the installation. The Contractor shall remove and replace all joints deemed to be improperly installed.

1.4 COORDINATION

- A. Coordinate layout and installation of hydronic piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.
- B. Coordinate pipe sleeve installations for foundation wall penetrations.
- C. Coordinate pipe fitting pressure classes with products specified in related Sections.
- D. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 3 Sections.
- E. Coordinate installation of pipe sleeves for penetrations through exterior walls and floor assemblies. Coordinate with requirements for firestopping for fire wall and floor assemblies.

1.5 EXTRA MATERIALS

- A. Water Treatment Chemicals: Furnish sufficient chemicals for initial system startup and for preventive maintenance for one (1) year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - 1. Pressure-Reducing Valves:
 - a. Amtrol, Inc.
 - b. Conbraco Industries, Inc.
 - c. ITT Bell & Gossett; ITT Fluid Technology Corp.
 - d. Spence Engineering Company, Inc.
 - e. Watts Industries, Inc.; Watts Regulators.

2.2 PIPING MATERIALS

- A. General: Refer to Part 3 "Piping Applications" Article for applications of pipe and fitting materials.

2.3 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.
- B. DWV Copper Tubing: ASTM B 306, Type DWV.

- C. Wrought-Copper Fittings: ASME B16.22. For hot and chilled water piping, Pro-Press fittings rated for 200 PSI operating pressure, 600 PSI test pressure and with 50 year warranty shall be permitted as an acceptable alternative for pipe sizes up to 4 inch system to be per ASTM B16. 18 or ASTM B16.22 with EPDM O-Rings.
- D. Wrought-Copper Unions: ASME B16.22.
- E. Solder Filler Metals: ASTM B 32, 95-5 tin antimony.
- F. Brazing Filler Metals: AWS A5.8, Classification BAg-1 (silver).

2.6 VALVES

- A. Gate, check, ball, and butterfly and calibrated balancing valves are specified in Division 23 Section 230523.

PART 3 – EXECUTION

3.1 PIPING APPLICATIONS

- A. Condensate Drain Lines: Type L drawn-temper copper tubing with soldered joints.

3.2 VALVE APPLICATIONS

- A. General Duty Valve Applications: Unless otherwise indicated, use the following valve types:
 - 1. Shutoff Duty: Ball and butterfly valves, (as indicated on the drawings).
- B. Install shutoff duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, unless only one piece of equipment is connected in the branch line. Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, and elsewhere as indicated.

3.4 PIPING INSTALLATIONS

- A. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- B. Install drains, consisting of a tee fitting, NPS 3/4 ball drain valve, at low points in piping system mains and elsewhere as required for system drainage.
- C. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- D. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- E. Unless otherwise indicated, install branch connections to mains using tee fittings in main pipe, with the takeoff coming out the bottom of the main pipe. For up-feed risers, install the takeoff coming out the top of the main pipe.
- F. Anchor piping for proper direction of expansion and contraction.

3.5 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and Supports." Comply with requirements below for maximum spacing of supports.
- B. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
 - 2. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
 - 3. Spring hangers to support vertical runs.
 - 4. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.
- C. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
 - 1. NPS 3/4": Maximum span, 5 feet; minimum rod size, 1/4 inch.
 - 2. NPS 1": Maximum span, 6 feet; minimum rod size, 1/4 inch.
 - 3. NPS 1-1/2" to 2": Maximum span, 8 feet; minimum rod size, 3/8 inch.
 - 4. NPS 2-1/2": Maximum span, 9 feet; minimum rod size, 3/8 inch.
- D. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors

3.6 FIELD QUALITY CONTROL

- A. Prepare hydronic piping according to ASME B31.9 and as follows:
 - 1. Leave joints, including welds, un-insulated and exposed for examination during test.
 - 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
 - 3. Flush system with clean water. Clean strainers.
 - 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
 - 5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
- B. Perform the following tests on hydronic piping:
 - 1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
 - 2. While filling system, use vents installed at high points of system to release trapped air. Use drains installed at low points for complete draining of liquid.
 - 3. Check expansion tanks to determine that they are not air bound and that system is full of water.
 - 4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times

the design pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed either 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A of ASME B31.9, "Building Services Piping."

5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks. Final test shall hold pressure for eight (8) hours.
6. Prepare written report of testing.

3.7 CLEANING

- A. Flush hydronic piping systems with clean water. Remove and clean or replace strainer screens.
After cleaning and flushing hydronic piping systems, but before balancing, remove disposable fine-mesh strainers in pump suction diffusers.

END OF SECTION 232113

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SECTION 232114 - HOT WATER HEATING SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION OF SYSTEM

- A. The new closed loop hot water piping system to accommodate this project.

1.3 HOT WATER PIPING SYSTEM EQUIPMENT

- A. New Hot Water Pumps: Refer to Section 23 21 23.
- B. New Expansion Tank: Refer to Section 23 05 17.
- C. New Heating Coils on Air Handling Unit: Refer to Section 23 73 00.

1.4 VALVES AND SPECIALTIES

- A. Furnish and install the valves and specialties as indicated on the drawings.
- B. All control valves, etc. to be furnished by the Building Automation Contractor.
- C. In branch piping at high points of the system: 1/8" manual air vent cocks.
- D. In the mains at high point of system: Anderson, Crane, Fischer, 1/2" automatic air vent traps with cast iron body and bronze float and valve mechanism, and with discharge piped to floor drain.
- E. At all low points of piping: A drain valve with hose fitting capped.

1.5 CONNECTIONS

- A. Furnish and install the following valves and specialties:
 - 1. At new hot water heating coils:
 - a. In supply connection to hot water heating coil: A butterfly valve or ball valve, strainer, and 3/4" drain valve with hose fitting capped.
 - b. In return connection to hot water heating coil: A butterfly valve and 3/4" drain valve with hose fitting capped.

- c. In return connection from the hot water heating coil: An automatic two-way water valve, furnished by Building Automation Contractor, as hereinafter specified.

1.6 INSTRUMENTS

- A. Furnish and install the following instruments:
 1. In hot water supply and return piping: Wells furnished by the Building Automation Contractor.
 2. In the piping, 1/2" pressure-temperature test plugs at the following locations for use with gauges and thermometers specified in Section 23 05 19:
 - a. At inlet and outlet of each air handling unit.

PART 2 – PRODUCTS – (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION 232114

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SECTION 232115 - CHILLED WATER SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION OF SYSTEM

- A. New chilled water piping to accommodate this project.

1.3 CONNECTIONS

- A. Furnish and install the following valves and specialties:
 1. In branch piping, where shown, and at high points of the system: One 1/8" manual air vent cock.
 2. In the mains at high points of the system: One Anderson, Crane, Fischer, Hoffman, or equal, 1/2" automatic air vent trap with cast iron body and bronze float and valve mechanism, and with discharge piped to floor drain except at fan coil units air vent discharge shall be piped to fan coil unit drain.
 3. Where shown, and at all low points of piping: A 3/4" drain valve with hose fitting capped.

1.4 VALVES AND SPECIALTIES

- A. Furnish and install valves and specialties as indicated on the drawings.
- B. In branch piping, where shown, and at high points of the system: One (1) 1/8" manual air vent cock.
- C. In the mains at high points of the system: One (1) 2" automatic air vent with discharge piped to floor drain. Refer to Section 23 05 19.
- D. Where shown, and at all low points of piping: A 3/4" drain valve with hose fitting capped.

PART 2 – PRODUCTS – (NOT USED)

PART 3 – EXECUTION – (NOT USED)

END OF SECTION 232115

SECTION 232116 – DUAL TEMPERATURE WATER SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION OF SYSTEM

- A. New dual temperature water piping to accommodate this project.

1.3 DUAL TEMPERATURE WATER SYSTEM EQUIPMENT

- A. New Coils in Fan Coil Units. Refer to Section 23 82 19.
- B. New Dual Temperature Water Pumps: Refer to Section 23 21 23.

1.4 CONNECTIONS

- A. Furnish and install the following valves and specialties:
 - 1. At water coils at each new Fan Coil Unit:
 - a. In return connection from water coil: A butterfly or ball valve and 3/4" drain valve with hose fitting capped.
 - b. In return connection from water coil: An automatic two-way water valve, furnished by Building Automation Contractor, as hereinafter specified.
 - c. In inlet to each coil: A ball valve, strainer, 3/4" drain valve, and a flange.
 - d. In outlet of each coil: A calibrated balancing valve, air vent, a ball valve, and a flange.
 - 2. At expansion tank:
 - a. In expansion line: A ball valve, an automatic air vent, and a Watts Regulator Co., Bell & Gossett, Cash, or equal, 3/4" ASME approved pressure relief valve set at 75 psi.
 - 3. In branch piping, where shown, and at high points of the system: One 1/8" manual air vent cock.
 - 4. In the mains at high points of the system: One Anderson, Crane, Fischer, Hoffman, or equal, 1/2" automatic air vent trap with cast iron body and bronze float and valve mechanism, and with discharge piped to floor drain except at fan coil units air vent discharge shall be piped to fan coil unit drain.
 - 5. Where shown, and at all low points of piping: A 3/4" drain valve with hose fitting capped.

1.5 INSTRUMENTS

- A. Furnish and install the following instruments:
 - 1. In the suction and discharge piping at each pump: One (1) pressure gauge.
 - 2. In the piping at the inlet of the pump: One (1) 9" industrial stem thermometer.
 - 3. In dual temperature water supply and return piping: Wells furnished by Building Automation Contractor.
 - 4. In dual temperature water supply and return piping: One (1) valve outlet for Building Automation Contractor's pressure sensors.
 - 5. In the piping, 1/2" pressure-temperature test plugs at the following locations as specified in Paragraph 23 05 19:
 - a. At inlet of coil.
 - b. At outlet of coil.
 - c. At inlet and outlet of strainer at coil.
 - d. At inlet and outlet of new temperature control valve at new coil.

1.6 VALVES AND SPECIALTIES

- A. Furnish and install valves and specialties as indicated on the drawings.
- B. All dual temperature water control valves, etc. to be furnished by the Building Automation Contractor.
- C. In branch piping, where shown, and at high points of the system: One (1) 1/8" manual air vent cock.
- D. In the mains at high points of the system: One (1) 2" automatic air vent with discharge piped to floor drain. Refer to Section 23 05 19.
- E. Where shown, and at all low points of piping: A 3/4" drain valve with hose fitting capped.

PART 2 – PRODUCTS – (NOT USED)

PART 3 – EXECUTION – (NOT USED)

END OF SECTION 232116

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SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Close-coupled, vertical in-line centrifugal pumps.
 - 2. Close-coupled, in-line circulators.

1.3 DEFINITIONS

- A. Buna-N: Nitrile rubber.
- B. EPT: Ethylene propylene terpolymer.

1.4 SUBMITTALS

- A. Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves. Include NPSH curve. Pump motors shall be non-overloading throughout its curve.
- B. Shop Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
- C. Operation and Maintenance Data: Submit 3 complete sets for each pump. Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain hydronic pumps through one source from a single manufacturer specializing in manufacturing, assembly, and field performance of pumps with a minimum five years experience.
- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of hydronic pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.
- B. Store pumps in dry location.
- C. Retain protective covers for flanges and protective coatings during storage.
- D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.
- E. Comply with pump manufacturer's written rigging instructions.

1.7 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.8 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Mechanical Seals: One mechanical seal for each pump.

1.9 WARRANTY

- A. The manufacturer shall provide a part and labor warranty for one (1) year after start-up, and shall correct product defects due to the following:
 - 1. Failure to comply with specifications.
 - 2. Faulty materials, equipment, appliances, or other items.
 - 3. Faulty workmanship.
- B. Defects corrected after energizing shall be accomplished at the time agreeable to the Owner.
- C. Product defects shall be corrected without charge to Owner.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 CLOSE COUPLED, VERTICAL IN-LINE CENTRIFUGAL PUMPS,

- A. Manufacturers:
1. Taco, Inc. (Basis of Design)
 2. Bell & Gossett; Div. of ITT Industries.
 3. Armstrong Pumps Inc.
 4. Weinman; Div. of Crane Pumps & Systems.
- B. Description: Factory-assembled and tested, centrifugal, bronze impeller, close-coupled, in-line pump; designed for installation with pump and vertically mounted motor shafts. Rate pump for 175-psig minimum working pressure and a continuous water temperature of 250 deg F Pump Construction:
1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gage tappings at inlet and outlet, vent/flush line from seal chamber to pump discharge, and companion flange connections.
 2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a stainless steel locking cap screw. Trim impeller to match specified performance.
 3. Pump Shaft: Stainless Steel, with copper-alloy shaft sleeve.
 4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and EPT bellows and gasket.
 5. Split coupling: High tensile aluminum.
- C. Motor: Single speed suitable for use with a variable frequency controller, with permanently lubricated ball bearings, unless otherwise indicated; and rigidly mounted to pump casing. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment.

2.3 CLOSE COUPLED, VERTICAL IN-LINE CENTRIFUGAL CIRCULATORS,

- A. Manufacturers:
1. Taco, Inc. (Basis of Design)
 2. Bell & Gossett; Div. of ITT Industries.
 3. Armstrong Pumps Inc.
 4. Weinman; Div. of Crane Pumps & Systems.
- B. Description: Factory-assembled and tested, centrifugal, overhung-impeller, close-coupled, in-line pump; designed for installation with pump and motor shafts mounted

horizontally or vertically. Rate pump for 175-psig minimum working pressure and a continuous water temperature of 250 deg F. Pump Construction:

1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gage tappings at inlet and outlet, and threaded companion-flange connections.
 2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a stainless steel locking cap screw. Trim impeller to match specified performance.
 3. Pump Shaft: Steel, with copper-alloy shaft sleeve.
 4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and EPT bellows and gasket. Include water slinger on shaft between motor and seal.
 5. Pump Bearings: Permanently lubricated ball bearings.
- C. Motor: Single speed, with permanently lubricated ball bearings, unless otherwise indicated; and rigidly mounted to pump casing. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

2.4 PUMP SPECIALTY FITTINGS

- A. Suction Diffuser: Angle pattern, 175-psig pressure rating, cast-iron body and end cap, pump-inlet fitting; with bronze startup and bronze or stainless-steel permanent strainers; bronze or stainless-steel straightening vanes; drain plug; and factory fabricated support.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine equipment foundations and anchor bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of work.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.
- C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONCRETE BASES

- A. Install concrete bases of dimensions indicated for pumps and controllers. Refer to Division 23 Section "Common Work Results for HVAC."
1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18 inch centers around full perimeter of base.
 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

- B. Cast-in-place concrete materials and placement requirements are specified in Division 03.

3.3 PUMP INSTALLATION

- A. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.
- B. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
- C. Suspend horizontally mounted, in-line centrifugal pumps independent of piping. Install pumps with motor and pump shafts horizontal. Use continuous-thread hanger rods and spring hangers of sufficient size to support pump weight. Spring hangers shall have a static deflection of not less than 2 inches. Vibration isolation devices are specified in Division 23 Section "Vibration Controls for HVAC Piping and Equipment." Hanger and support materials are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment"
- D. First paragraph and subparagraphs below are for base-mounted pumps that require design considerations for size, mass, and isolation from other structural members. A foundation is not an inertia base. Inertia Bases are specified in Division 23 Section "Vibration Controls for HVAC Piping and Equipment."
- E. Install vertical in-line pumps with flange connections to inlet and discharge piping per all requirements and recommendations of the pump manufacturer. Provide steel pipe support stands for adjacent connecting piping per all requirements of the pump manufacturer. Do not provide support stands directly under the pump unless specifically recommended by the pump manufacturer.

3.4 ALIGNMENT

- A. Align pump and motor shafts and piping connections after setting on foundation, grout has been set and foundation bolts have been tightened, and piping connections have been made.
- B. Comply with pump and coupling manufacturers' written instructions.
- C. Adjust pump and motor shafts for angular and offset alignment. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill base plate with non-shrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.5 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
- D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- E. Install suction diffuser and shutoff valve on suction side of pumps.
- F. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- G. Install pressure gages on pump suction and discharge, at integral pressure-gage tapping, or install single gage with multiple input selector valve.
- H. Install electrical connections for power, controls, and devices.
- I. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- J. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers on suction piping.
 - 4. Perform the following startup checks for each pump before starting:
 - a. Verify bearing lubrication.
 - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - c. Verify that pump is rotating in the correct direction.
 - 5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
 - 6. Start motor.
 - 7. Open discharge valve slowly.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 232123

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SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes refrigerant piping used for air conditioning applications.

1.2 SUBMITTALS

- A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for thermostatic expansion valves, solenoid valves, and pressure-regulating valves.
- B. Shop Drawings: The HVAC Contractor shall submit diagrams for all refrigerant piping systems that are either furnished or approved by the manufacturer of the refrigeration equipment. Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationship between piping and equipment.
 - 1. Size piping and design the actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes, to ensure proper operation and compliance with warranties of connected equipment.
- C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- D. Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals specified in Division 1.

1.3 QUALITY ASSURANCE

- A. ASHRAE Standard: Comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."
- B. ASME Standard: Comply with ASME B31.5, "Refrigeration Piping."
- C. UL Standard: Provide products complying with UL 207, "Refrigerant-Containing Components and Accessories, Non electrical"; or UL 429, "Electrically Operated Valves."

1.4 COORDINATION

- A. Coordinate layout and installation of refrigerant piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.
- B. Coordinate pipe sleeve installations for penetrations in exterior walls and floor assemblies. Coordinate with requirements for firestopping specified in Division 7 Section "Through-Penetration Firestop Systems" for materials and methods for sealing pipe penetrations through fire and smoke barriers.

- C. Coordinate pipe fitting pressure classes with products specified in related Sections.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tube: ASTM B 280, Type ACR
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Wrought-Copper Unions: ASME B16.22.

2.2 VALVES

- A. Diaphragm Packless Valves: 500-psig working pressure and 275 Deg F working temperature; globe design with straight-through or angle pattern; forged-brass or bronze body and bonnet, phosphor bronze and stainless-steel diaphragms, rising stem and hand wheel, stainless-steel spring, nylon seat disc, and with solder-end connections.
- B. Packed-Angle Valves: 500 psig working pressure and 275 Deg F working temperature; forged-brass or bronze body, forged-brass seal caps with copper gasket, back seating, rising stem and seat, molded stem packing, and with solder-end connections.
- C. Service Valves: 500 psig pressure rating; forged-brass body with copper stubs, brass caps, removable valve core, integral ball check valve, and with solder-end connections.
- D. Solenoid Valves: Comply with ARI 760; 250 Deg F temperature rating and 400-psig working pressure; forged brass, with polytetrafluoroethylene valve seat, 2-way, straight-through pattern, and solder-end connections; manual operator; fitted with suitable NEMA 250 enclosure of type required by location, with 1/2" conduit adapter and holding coil.

2.3 REFRIGERANT PIPING SPECIALITIES

- A. The Contractor shall provide all refrigerant piping accessories as indicated on the project design drawings and as recommended by the condensing unit manufacturer.
- B. Straight- or Angle-Type Strainers: 500 psig working pressure; forged-brass or steel body with stainless-steel wire or brass-reinforced Monel screen of 80 to 100 mesh in liquid lines up to 1-1/8", 60 mesh in larger liquid lines, and 40 mesh in suction lines; with screwed cleanout plug and solder-end connections.
- C. Moisture/Liquid Indicators: 430 psig maximum working pressure and 200°F operating temperature; all-brass body with replaceable, polished, optical viewing window with color-coded moisture indicator; with solder-end connections.
- D. Replaceable-Core Filter-Dryers: 350 psig maximum working pressure; heavy gage protected with corrosion-resistant-painted steel shell, flanged ring and spring, ductile-

iron cover plate with steel cap screws; wrought-copper fittings for solder-end connections; with replaceable-core kit, including gaskets and the following:

2.4 REFRIGERANTS

- A. Puron.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Pipe: Type ACR drawn-copper tubing
- B. Fittings: Wrought copper

3.2 VALVE APPLICATIONS

- A. Install diaphragm packless or packed-angle valves in suction and discharge lines of compressor and on each side of strainers.
- B. Install diaphragm packless or packed-angle valves on each side of strainers and dryers, in liquid and suction lines at evaporators, and elsewhere as indicated.
- C. Install solenoid valves where required by the condensing unit manufacturer.
 - 1. Install solenoid valves in horizontal lines with coil at top.
 - 2. Electrical wiring for solenoid valves is specified in Division 26 Sections. Coordinate electrical requirements and connections.

3.3 SPECIALTY APPLICATIONS

- A. Install liquid indicators in liquid line leaving condenser.
- B. Install moisture-liquid indicators in liquid lines between filter-dryers and thermostatic expansion valves and in liquid line to receiver.
- C. Install replaceable-core filter-dryers in vertical liquid line and before each solenoid valve.
- D. Install solenoid valves in liquid line where required to stop flow of oil and refrigerant into suction line when system shuts down.

3.4 PIPING INSTALLATION

- A. Install refrigerant piping according to ASHRAE 15. All refrigerant piping must be of size as required by the condensing unit manufacturer. Provide all required piping accessories as recommended and required by the condensing unit manufacturer.
- B. Basic piping installation requirements are specified in Division 23 Section 230515 "General Piping Requirements".

- C. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- D. Arrange piping to allow inspection and service of compressor and other equipment. Install valves and specialties in accessible locations to allow for service and inspection.
- E. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation. Use sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.
- F. Slope refrigerant piping as follows:
 - 1. Install horizontal suction lines with a uniform slope downward to compressor.
 - 2. Install traps and double risers to entrain oil in vertical runs.
 - 3. Liquid lines may be installed level.
- G. Install unions to allow removal of solenoid valves and pressure-regulating valves and at connections to compressors and evaporators.
- H. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties.
- I. Hanger, support, and anchor products are specified in Division 23 Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- J. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
- K. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
 - 1. NPS 1/2: Maximum span, 60"; minimum rod size, 1/4".
 - 2. NPS 5/8: Maximum span, 60"; minimum rod size, 1/4".
 - 3. NPS 1 & larger: Maximum span, 72"; minimum rod size, 1/4".

3.5 PIPE JOINT CONSTRUCTION

- A. Braze joints according to applicable Division 23 sections.
- B. Fill pipe and fittings with nitrogen during brazing to prevent scale formation.

3.6 FIELD QUALITY CONTROL

- A. Test and inspect refrigerant piping according to ASME B31.5, Chapter VI.
 - 1. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure.
 - 2. Test high and low pressure side piping of each system at not less than the lower of the design pressure or the setting of pressure relief device protecting high and low side of system.

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

3.7 ADJUSTING

- A. Adjust high and low pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- B. Adjust set point temperature of the conditioned air to the system design temperature.
- C. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
 1. Check compressor oil level above center of sight glass.
 2. Open compressor suction and discharge valves.
 3. Open refrigerant valves, except bypass valves that are used for other purposes.

3.8 SYSTEM CHARGING

- A. Charge system using the following procedures:
 1. Install core in filter-dryer after leak test but before evacuation.
 2. Evacuate entire refrigerant system with a vacuum pump to a vacuum of 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
 3. Charge system with a new filter-dryer core in charging line. Provide full-operating charge.

END OF SECTION 232300

SECTION 232500 - HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following HVAC water-treatment systems:
 - 1. HVAC water-treatment chemicals.
 - 2. Cleaning and Testing Hydronic Piping System.

1.3 DEFINITIONS

- A. EEPROM: Electrically erasable, programmable read-only memory.
- B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
- C. TDS: Total dissolved solids.
- D. UV: Ultraviolet.
- E. AABC: Associated Air Balance Council.
- F. NEBB: National Environmental Balancing Bureau.
- G. TAB: Testing, adjusting, and balancing.
- H. TABB: Testing, Adjusting, and Balancing Bureau.
- I. TAB Specialist: An entity engaged to perform TAB Work.

1.4 COORDINATION

- A. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.
- B. Perform pressure tests on water distribution systems have been satisfactorily completed.

1.5 TESTING

- A. Provide equipment for testing, including necessary pumps, air compressors, hoses, gages, etc. Make necessary temporary connections to perform testing. Test piping systems before

insulation and control devices are installed wherever feasible. Tests shall be performed before any work is concealed, covered, or painted.

- B. Preliminary testing using air may be performed by the contractor to void delays in filling and draining of system for repairs. However, final test shall be hydrostatic unless specified otherwise.
- C. A test fails if a leakage is observed or if the pressure drop exceeds 5% of test pressure over the duration of specified time.
- D. Repair pipe or fittings which fail required test, by disassembly and reinstallation, using new materials to extent required to overcome leakage. Do not use chemicals, stop-leak compounds, mastics, or other temporary repair methods.
- E. After successful, final test, which must be witnessed by the Owner, Owner's Representative or Engineer, drain all water from system.
- F. Hydrostatic tests shall be maintained for a minimum of eight (8) hours; air tests shall be maintained for a minimum of twenty-four (24) hours.
- G. Water Systems: All HVAC hydronic piping shall be tested and made tight initially under air pressure and then under hydrostatic pressure each equal to 1-1/2 times the working pressure but in not case less than 125 PSI.

1.6 PERFORMANCE REQUIREMENTS

- A. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment.
- B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.
- C. Closed hydronic systems, including hot-water heating and chilled water, shall have the following water qualities:
 - 1. pH: Maintain a value within 9.0 to 10.5.
 - 2. "P" Alkalinity: Maintain a value within 100 to 500 ppm.
 - 3. Boron: Maintain a value within 100 to 200 ppm.
 - 4. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm.
 - 5. Soluble Copper: Maintain a maximum value of 0.20 ppm.
 - 6. TDS: Maintain a maximum value of 10 ppm.
 - 7. Ammonia: Maintain a maximum value of 20 ppm.
 - 8. Free Caustic Alkalinity: Maintain a maximum value of 20 ppm.
 - 9. Microbiological Limits:
 - a. Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/ml.
 - b. Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/ml.
 - c. Nitrate Reducers: Maintain a maximum value of 100 organisms/ml.
 - d. Sulfate Reducers: Maintain a maximum value of 0 organisms/ml.
 - e. Iron Bacteria: Maintain a maximum value of 0 organisms/ml.

1.7 SUBMITTALS

- A. Strategies and Procedures Plan: Within 60 days of Contractor's Notice to Proceed, submit cleaning and testing strategies and step-by-step procedures as specified in "Preparation" Article.
- B. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for the following products:
 - 1. Bypass feeders.
 - 2. Water meters.
 - 3. Inhibitor injection timers.
 - 4. pH controllers.
 - 5. TDS controllers.
 - 6. Biocide feeder timers.
 - 7. Chemical solution tanks.
 - 8. Injection pumps.
 - 9. Chemical test equipment.
 - 10. Chemical material safety data sheets.
- C. Shop Drawings: Pretreatment and chemical, treatment equipment showing tanks, maintenance space required, and piping connections to HVAC systems. Include plans, elevations, sections, details, and attachments to other work.
- D. Field quality-control test reports.
- E. Other Informational Submittals:
 - 1. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in the "Performance Requirements" Article above.
 - 2. Water Analysis: Illustrate water quality available at Project site.
 - 3. Passivation Confirmation Report: Verify passivation of galvanized-steel surfaces, and confirm this observation in a letter to Architect.

1.8 QUALITY ASSURANCE

- A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.
- B. All cleaning and flushing of piping shall be scheduled in advance with the Owner and the Commissioning Agent in order that they can witness the process.

1.9 MAINTENANCE SERVICE

- A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion, scale formation, and biological growth for cooling, chilled-water piping, hot-water piping, and equipment. Services and chemicals shall be provided for a period of two years from date of Substantial Completion, and shall include the following:
 - 1. Initial water analysis and HVAC water-treatment recommendations.

2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
3. Periodic field service and consultation.
4. Customer report charts and log sheets.
5. Laboratory technical analysis.
6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Aqua-Chem, Inc.; Cleaver-Brooks Div.
 2. GE Betz.
 3. HVC Chemical.
 4. Dow Chemical.
 5. Industrial Water Solutions.

2.2 CLEANING

- A. All piping systems must have been satisfactory tested before systems are cleaned. Also, before any system is placed in service and before start-up of any equipment, each contractor shall clean piping, fixtures, and equipment installed under their respective contracts, and shall remove other foreign matter detrimental to the operation of the system.
- B. All Water Systems shall be thoroughly washed out with treated water until the systems are clean and passivated and free of all scale, dirt, weld beads, solder, or other deleterious matter. The contractor shall provide the following chemicals or approved equals:

Water Systems – H. D. Cleaner Model No. 203

- C. All strainers shall then be cleaned.
- D. Flush lines utilizing temporary water pumps as required. Contractor to finish an ultra fine strainer for pumps. Contractor shall also provide all temporary valved by-passes to be installed in the piping as required to circulate cleaners.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper cleaning and testing of systems.

- B. Examine system installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- C. Report deficiencies discovered before and during performance of cleaning and painting procedures. Observe and record system reactions to changes in conditions.

3.2 WATER ANALYSIS

- A. Perform an analysis of supply water to determine quality of water available at Project site.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.
- C. Confirm applicable electrical requirements in Division 26 Sections for connecting electrical equipment.
- D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B. Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
 - 1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
 - 2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
 - 3. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
 - 4. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 5. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.

6. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
 7. Repair leaks and defects with new materials and retest piping until no leaks exist.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. At six-week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis advising Owner of changes necessary to adhere to Part 1 "Performance Requirements" Article.
- F. Comply with ASTM D 3370 and with the following standards:
1. Silica: ASTM D 859.
 2. Steam System: ASTM D 1066.
 3. Acidity and Alkalinity: ASTM D 1067.
 4. Iron: ASTM D 1068.
 5. Water Hardness: ASTM D 1126.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.
- B. Training: Provide a "how-to-use" self-contained breathing apparatus video that details exact operating procedures of equipment.

END OF SECTION 23 25 00

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes metal ducts for supply, return, outside, and exhaust air-distribution systems in pressure classes from minus 2 to plus 4 inch w.g. Metal ducts are to include the following:
 - 1. Rectangular ducts and fittings.
 - 2. Single-wall, round spiral-seam ducts and formed fittings.
 - 3. Duct liner.

1.2 SYSTEM DESCRIPTION

- A. Duct system design, as indicated, has been used to select size and type of air moving and distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by the Engineer. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

1.3 SUBMITTALS

- A. Shop Drawings: The Sheet Metal Contractor shall prepare ductwork drawings, at a minimum scale of 1/4" = 1'-0", in ACAD Release 2000 or newer edition. Submit an electronic copy of ductwork drawings for review and approval by the Architect/Engineer before coordination drawings are submitted for coordination. Drawings may be submitted to the Architect/Engineer in stages if required to expedite work. Do not proceed with fabrication of ductwork until submitted drawings are approved by the Architect/Engineer

1.3 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports and AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- B. NFPA Compliance:
 - 1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
 - 2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified.

2.2 SHEET METAL MATERIALS

- A. Comply with the most current version of SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653 and having G60 (Z180) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
- C. Carbon-Steel Sheets: ASTM A 366 cold-rolled sheets; commercial quality; with oiled, matte finish for exposed ducts.
- D. Stainless Steel: ASTM A 480, Type 304, and having a No. 2D finish for concealed ducts and mill for exposed ducts.
- E. Aluminum Sheets: ASTM B 209, alloy 3003, tempered H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- F. Exposed ductwork shall be suitable for painting (paint grip) in field by General Contractor.
- G. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.
- H. Tie Rods: Galvanized steel, 1/4 inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 SEALANT MATERIALS

- A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics.
- B. Joint and Seam Tape: 2 inches wide; glass-fiber-reinforced fabric.
- C. Tape Sealing System: Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
- D. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.
- E. Solvent-Based Joint and Seam Sealant: One-part, non-sag, solvent-release-curing, polymerized butyl sealant formulated with a minimum of 75 percent solids.
- F. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.
- G. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.4 HANGERS AND SUPPORTS

- A. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 - 2. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
- B. Hanger Materials: Galvanized sheet steel or threaded steel rod.
 - 1. Strap and Rod Sizes: Comply with the most current version of SMACNA's "HVAC Duct Construction Standards-Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.
 - 2. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.
- C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- D. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36.
 - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 - 2. Supports for Stainless-Steel Ducts: Stainless-steel support materials.
 - 3. Supports for Aluminum Ducts: Aluminum support materials unless materials are electrolytically separated from ducts.

2.5 RECTANGULAR DUCT FABRICATION

- A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to the most current version of SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.
 - 1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
 - 2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- B. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.
 - 1. Manufacturers:
 - a. Ductmate Industries, Inc.
 - b. Nexus Inc.
 - c. Ward Industries, Inc.

- C. Formed-On Flanges: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Figure 1-4, using corner, bolt, cleat, and gasket details.
 - 1. Duct Size: Maximum 30 inches wide and up to 2-inch wg pressure class.
 - 2. Longitudinal Seams: Pittsburgh lock sealed with non-curing polymer sealant.
- D. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359 inch thick or less, with more than 10 sq. ft. of non-braced panel area unless ducts are lined.

2.6 ROUND DUCT AND FITTING FABRICATION

- A. Round, Spiral Lock Seam Ducts: Fabricate supply ducts of galvanized steel according to the most current version of SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
 - 1. Manufacturers:
 - a. Lindab
 - b. McGill AirFlow Corporation.
 - c. SEMCO Incorporated.
- B. Duct Joints:
 - 1. Minus 2 inches wg to plus 2 inches wg pressure class
 - a. Ducts up to 20 inches in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
 - b. Ducts 21 to 72 Inches in Diameter: Three-piece, gasketed, flanged joint consisting of two (2) internal flanges with sealant and one (1) external closure band with gasket.
 - c. Joints shall be made with pop rivets or sheet metal screws and sealed.
 - 2. Less than minus 2 inches wg or more than plus 2 inches wg pressure class
 - a. All fitting ends shall come factory equipped with a double lipped, U-profile, EPDM rubber gasket. Gasket shall be manufactured to gauge and flexibility so as to insure that system will meet all of the performance criteria set forth in the manufacturer=s literature. Gasket shall be classified by Underwriter=s Laboratories to conform to ASTM E84-91a and NFPA 90A flame spread and smoke developed ratings of 25/50.
 - b. All fitting ends shall be calibrated to manufacturer=s published dimensional tolerance standard and associated spiral duct.
 - c. All fitting ends from 3" to 24" Dia. shall have rolled over edges for added strength and rigidity.
 - d. All elbows from 3" to 12" Dia. shall be 2-piece die stamped and continuously stitch welded. All elbows 14" Dia. and larger shall be standing seam gorelock construction and internally sealed.
 - e. The radius of all 90° and 45° elbows shall be 1.5 times the elbow diameter.
 - f. All fittings that are of either spot welded or button punched construction shall be internally sealed.
 - g. Fittings shall be connected with self tapping sheet metal screws or pressure

proof pop rivets in quantity and procedure per manufacturer=s recommendations.

- C. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA's "1985 HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts.
- D. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.
- E. Fabricate elbows using die-formed, gored, pleated, or mitered construction. Bend radius of die-formed, gored, and pleated elbows shall be 1-1/2 times duct diameter. Unless elbow construction type is indicated, fabricate elbows as follows:
 - 1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
 - 2. Die-Formed Elbows for Sizes through 12 Inches in Diameter with 2-piece welded construction, 24 ga.
 - 3. Round Elbows Larger Than 14 Inches in Diameter: Fabricate gored elbows 22 ga. for 16 inches through 26 inches, 20 ga. for 28 inches and above.
- F. All tees and crosses shall be conical fittings.
- G. Round connections to rectangular ducts shall be made with bellmouth fittings.
- H. All connections to round ductwork shall be made with full body fittings. Side taps and saddles are not acceptable.

2.7 DUCT LINER

- A. Fibrous-Glass Liner: Comply with NFPA 90A or NFPA 90B and with NAIMA AH124.
 - 1. Manufacturers:
 - a. CertainTeed Corp.; Insulation Group.
 - b. Johns Manville International, Inc.
 - c. Knauf Fiber Glass GmbH.
 - d. Owens Corning.
 - 2. Materials: ASTM C 1071; surfaces exposed to airstream shall be coated to prevent erosion of glass fibers.
 - a. Thickness: 1 inch.
 - b. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.
 - c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
 - d. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
 - e. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing

leakage in duct.

- 1) Tensile Strength: Indefinitely sustain a 50-lb tensile, dead-load test perpendicular to duct wall.
- 2) Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into airstream.
- 3) Adhesive for Attaching Mechanical Fasteners: Comply with fire-hazard classification of duct liner system.

2.8 APPLICATION OF LINER IN RECTANGULAR DUCTS

- A. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
- B. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
- C. Butt transverse joints without gaps and coat joint with adhesive.
- D. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
- E. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.
- F. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
- G. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
- H. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
 1. Fan discharges.
 2. Intervals of lined duct preceding unlined duct.
 3. Upstream edges of transverse joints in ducts where air velocities are greater than 2500 fpm or where indicated.
- I. Terminate inner ducts with build-outs attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated build-outs (metal hat sections) or other build-out means are optional; when used, secure build-outs to duct walls with bolts, screws, rivets, or welds.

PART 3 – EXECUTION

3.1 DUCT APPLICATIONS

- A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:
1. Supply Ducts (from air handling units to VAV terminal units), (Positive Pressure): 4 inch w.g. pressure class.
 2. Supply Ducts: (from terminal units to air devices), (Positive Pressure): 2-inch w.g. pressure class.
 3. Return Ducts: (from air devices to air handling units) (Negative Pressure): 2-inch w.g. pressure class.
 4. Exhaust Ducts, (Negative Pressure): 2-inch w.g. pressure class.
 6. Outside Air Ducts, (Positive and Negative Pressure): 2-inch pressure class.
 7. Combustion Air & Transfer Air (Positive Pressure): 2 inch pressure class.
- B. All ducts shall be of galvanized steel construction except for Type 2 exhaust hoods and clothes dryer exhaust ducts which shall be of aluminum construction and Type 1 exhaust hood ductwork which shall be welded 304 stainless steel. Type 1 and Type 2 exhaust hood exhaust ductwork shall comply with the requirements of the Ohio Mechanical Code.

3.2 DUCT INSTALLATION

- A. Construct and install ducts according to the most current version of SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
- B. Install round ducts in lengths not less than 10 feet unless interrupted by fittings.
- C. Install ducts with fewest possible joints.
- D. Install fabricated fittings for changes in directions, size, and shape and for connections. Fittings indicated on drawings are diagrammatic and are for information purposes only.
- E. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches, with a minimum of three (3) screws in each coupling.
- F. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- I. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.
- J. Coordinate layout with suspended ceiling, fire-dampers, lighting layouts, and similar finished work.

- K. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws. Longitudinal joints shall be on the top side of horizontal ducts.
- L. Electrical Equipment Spaces: Route ducts to avoid passing through electrical equipment spaces and enclosures.
- M. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.
- N. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant.
- O. Protect duct interiors from the elements and foreign materials until building is enclosed. Follow SMACNA's "Duct Cleanliness for New Construction." All ductwork is to be maintained at the SMACNA Intermediate Cleanliness level.
- P. This Contractor shall paint interiors of metal ducts, that do not have duct liner, for 24 inches upstream and downstream of duct mounted registers and grilles. Apply one (1) coat of flat, black, latex finish coat over a compatible galvanized-steel primer.
- Q. Duct dimensions on drawings are inside clear dimensions.

3.3 SEAM AND JOINT SEALING

- A. Seal all duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure class indicated.
- B. Seal ducts before external insulation is applied.

3.4 HANGING AND SUPPORTING

- A. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.
- B. Support vertical ducts at maximum intervals of 6 feet and at each floor.
- C. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.
- D. Install concrete inserts before placing concrete.
- E. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 1. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

3.5 CONNECTIONS

- A. Make connections to equipment with flexible connectors.
- B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 DUCT CLEANING

- A. Clean new duct system(s) before testing, adjusting, and balancing.
- B. Use service openings for entry and inspection.
 - 1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Division 23 Section "Air Duct Accessories" for access panels and doors.
 - 2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
 - 3. Remove and reinstall ceiling to gain access during the cleaning process.
- C. Particulate Collection and Odor Control:
 - 1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
 - 2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
- D. Clean the following components by removing surface contaminants and deposits:
 - 1. Air outlets and inlets (registers, grilles, and diffusers).
 - 2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 - 3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 - 4. Coils and related components.
 - 5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
 - 6. Supply-air ducts, dampers, actuators, and turning vanes.
 - 7. Dedicated exhaust and ventilation components and makeup air systems.
- E. Mechanical Cleaning Methodology:
 - 1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
 - 2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
 - 3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.

4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.6 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual" and prepare test reports:
 1. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 2. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test the entire system at the maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven (7) days' advance notice for testing.
 3. Maximum Allowable Leakage: Comply with requirements for Leakage Class 3 for round ducts, Leakage Class 12 for rectangular ducts in pressure classes lower than and equal to 2 inch w.g. (both positive and negative pressures) and leakage class 6 for pressure classes above 2 inch w.g.
 4. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.

END OF SECTION 233113

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SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Backdraft dampers.
2. Volume dampers.
3. Motorized Control Dampers.
4. Outside air intake and exhaust air hoods.
5. Turning vanes.
6. Duct-mounting access doors.
7. Flexible connectors.
8. Flexible ducts.
9. Duct accessory hardware.

B. The motorized automatic control dampers are supplied by the HVAC Contractor. The HVAC contractor shall install the motorized automatic control dampers. TCC shall provide operators and linkage.

1.2 SUBMITTALS

A. Product Data: For the following:

1. Backdraft dampers.
2. Volume dampers.
3. Motorized Control Dampers.
4. Outside air intake and exhaust air hoods.
5. Turning vanes.
6. Duct-mounting access doors.
7. Flexible connectors.
8. Flexible ducts.

1.3 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 – PRODUCTS

2.1 Manufacturers

A. In other part 2 articles where subparagraphs titles below introduce lists, the following requirements apply for product selection.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified.

2.2 SHEET METAL MATERIALS

- A. Comply with the most current version of SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.
- B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653 and having G60 (Z180) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
- C. Stainless Steel: ASTM A 480.
- D. Aluminum Sheets: ASTM B 209, alloy 3003, tempered H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 BACKDRAFT DAMPERS

- A. Manufacturers:
 - 1. Air Balance, Inc.
 - 2. American Warming and Ventilating.
 - 3. Lindab (medium velocity basis of design)
 - 4. Greenheck.
 - 5. Prefco Products, Inc.
 - 6. Ruskin Company. (low velocity basis of design)
- B. Description: Multiple-blade, parallel action gravity balanced, with center-pivoted blades of maximum 6-inch width, with sealed edges, assembled in rattle-free manner with 90-degree stop, steel ball bearings, and axles; adjustment device to permit setting for varying differential static pressure.
- C. Frame: 0.090 extruded aluminum, with mitered corners and mounting flange.
- D. Blades: 0.025-inch-thick, roll-formed aluminum.
- E. Blade Seals: Vinyl.
- F. Blade Axles: Galvanized steel.
- G. Tie Bars and Brackets: Galvanized steel.
- H. Return Spring: Adjustable tension.

2.4 VOLUME DAMPERS

A. Manufacturers:

1. Air Balance, Inc.
2. American Warming and Ventilating
3. Lindab (Medium velocity Basis of Design)
3. McGill AirFlow Corporation
4. Metalaire, Inc.
5. Ruskin Company (Low velocity Basis of Design)

B. General Description: Factory fabricated, with required hardware and accessories. Stiffen damper blades for stability. Include dial type quadrant handle locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class. Provide stand-off assembly for all balancing dampers that are installed in insulated ducts.

C. Standard Volume Dampers: Single-blade up to 6" blade width and opposed multi-blade on 8" and larger blade width, standard leakage rating, and suitable for horizontal or vertical applications.

1. Steel Frames: 22 gauge, hat-shaped, galvanized sheet steel channels, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
2. Roll-Formed Steel Blades: 22 gauge galvanized sheet steel.
3. Blade Axles: Galvanized steel.
4. Bearings: Molded synthetic.
5. Tie Bars and Brackets: Aluminum.
6. Tie Bars and Brackets: Galvanized steel.

D. Low velocity rectangular: Ruskin Model MD25

E. Low velocity round: Ruskin Model MDRS25

F. Medium velocity round: Lindab Model DRU

2.5 MOTORIZED CONTROL DAMPERS

A. Manufacturers:

1. Air Balance, Inc.
2. American Warming and Ventilating.
3. Greenheck.
4. Ruskin Company.

B. General Description: AMCA-rated, parallel or opposed blade design; minimum of 11 gauge thick, galvanized-steel frames with holes for duct mounting with maximum blade width of 8 inches.

1. Secure blades to 1/2 inch diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
2. Operating Temperature Range: From minus 40 to plus 200 deg F .

3. Provide parallel or opposed-blade design with inflatable seal blade edging, or replaceable rubber seals, rated for leakage at less than 10 cfm per sq. ft. of damper area, at differential pressure of 4 inch wg when damper is being held by torque of 50 in. x lbf; when tested according to AMCA 500D.
4. Coordinate damper configuration with the Temperature Control Contractor including blade and rod as well as the operator mounting.

2.6 OUTDOOR AIR INTAKE AND EXHAUST AIR HOODS

A. General Description:

1. Ventilator shall be low silhouette for exhaust or intake applications
2. Units for ducted application.

B. Hood and Base:

1. Material Type: Aluminum.
2. Hood Constructed of formed, arched panels with interlocking seams
3. Vertical end panels shall be fully locked into hood end panels
4. Base height minimum 5 inches
5. Curb cap shall be six inches larger than throat size
6. Curb cap shall have pre-punched mounting holes for installation

C. Birdscreen:

1. Constructed of ½ inch aluminum mesh.
2. Mounted horizontally across the intake area of the hood

D. Hood Support:

1. Constructed of galvanized steel and fastened so the hood can either be removed completely from the base or hinged open

E. Accessories:

1. Roof Curbs: Provide 12 inch high insulated roof curb per requirements of Section 230500 and as detailed on the project drawings.
2. Hinged Access: Provide hinged connection from hood to base suitable for roof access to the connecting ductwork. Provide hinge assembly complete with locking device that secures the hood in the open position.

2.7 TURNING VANES

A. Fabricate to comply with the most current version of SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for vanes and vane runners. Vane runners shall automatically align vanes.

B. Manufactured Turning Vanes: Fabricate 1-1/2 inch wide, airfoil-vane, curved blades of galvanized sheet steel set 3/4 inch o.c.; support with bars perpendicular to blades set 2 inches o.c.; and set into vane runners suitable for duct mounting.

1. Manufacturers:

- a. Ductmate Industries, Inc.
- b. Duro Dyne Corp.
- c. METALAIRE, Inc.

2.8 DUCT-MOUNTING ACCESS DOORS

- A. General Description: Fabricate doors airtight and suitable for duct pressure class.
- B. Door: Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include piano hinge and cam latches.
 1. Manufacturers:
 - a. American Warming and Ventilating.
 - b. CESCO Products.
 - c. Ductmate Industries, Inc.
 - d. Greenheck.
 - e. McGill AirFlow Corporation.
 - f. Ruskin
 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 3. Provide number of hinges and locks as follows:
 - a. Less Than 12 Inches square: Secure with two (2) sash locks.
 - b. Up to 18 Inches Square: Two (2) sash locks.
 - c. Up to 24 by 48 Inches: Secure with two (2) compression locks.
- C. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.
- D. Insulation: 1-inch thick, fibrous-glass or polystyrene-foam board.

2.9 FLEXIBLE CONNECTORS

- A. Manufacturers:
 1. Ductmate Industries, Inc.
 2. Duro Dyne Corp.
 3. Ventfabrics, Inc.
- B. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.
- C. Metal-Edged Connectors: Factory fabricated with a fabric strip 3" to 6" wide attached to two strips of 2-3/4-inch wide, 0.028-inch thick, galvanized sheet steel or 0.032-inch thick aluminum sheets. Select metal compatible with ducts.
- D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 1. Minimum Weight: 26 oz./sq. yd.
 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
 3. Service Temperature: Minus 40 to plus 200 deg F.

- E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
 - 1. Minimum Weight: 24 oz./sq. yd..
 - 2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
 - 3. Service Temperature: Minus 50 to plus 250 deg F.

2.10 FLEXIBLE DUCTS

- A. Manufacturers:
 - 1. Flexmaster U.S.A., Inc.
 - 2. Hart & Cooley, Inc.
 - 3. McGill AirFlow Corporation.
- B. Non-insulated-Duct Connectors: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire.
 - 1. Pressure Rating: 4-inch wg positive and 0.5-inch wg negative.
 - 2. Maximum Air Velocity: 4000 fpm.
 - 3. Temperature Range: Minus 20 to plus 175 deg F.
- C. Insulated-Duct Connectors: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor barrier film.
 - 1. Pressure Rating: 4-inch wg positive and 0.5-inch wg negative.
 - 2. Maximum Air Velocity: 4000 fpm.
 - 3. Temperature Range: Minus 20 to plus 175 deg F.
- D. Flexible Duct Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action, in sizes 3 through 18 inches to suit duct size.

PART 3 – EXECUTION

3.1 APPLICATION AND INSTALLATION

- A. Install duct accessories according to applicable details in the most current version of SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Install backdraft dampers on exhaust fans or exhaust ducts where indicated.
- D. Provide balancing dampers at points on supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing. Install at a minimum of two (2) duct widths from branch takeoff. Locking quadrants shall be easily accessible and shall be installed on the outside of the duct insulation.

- E. Install all intake or exhaust air hoods on insulated roof curbs per all requirements of the hood manufacturer. The HVAC contractor is to provide flashing for all roof hoods.
- F. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:
 - 1. On both sides of duct coils.
 - 2. Downstream from volume dampers and equipment.
 - 3. Adjacent to fire dampers, providing access to reset or reinstall fusible links.
 - 4. To interior of ducts for cleaning; before and after each change in direction, at maximum 50-foot spacing. Duct mounted grilles will replace access doors for duct cleaning.
 - 5. On sides of ducts where adequate clearance is available.
- G. Install the following sizes for duct-mounting, rectangular access doors: Based on the following maximum duct dimensions:
 - 1. 9" and smaller: 6" x 8" door size.
 - 2. 10" to 12": 9" x 12" door size.
 - 3. 13" to 16": 12" x 16" door size.
 - 4. 18" and larger: 14" x 14" door size.
- H. Label access doors according to Division 23 Section "Mechanical Identification."
- I. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.
- J. Connect terminal units to supply ducts with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.
- K. Connect diffusers to low pressure ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place. See detail on drawings.
- L. Connect flexible ducts to metal ducts with draw bands.

3.2 ADJUSTING

- A. Adjust duct accessories for proper settings.
- B. Final positioning of manual-volume dampers is specified in Division 23 Section "Testing, Adjusting, and Balancing."

END OF SECTION 233300

SECTION 233416 - CENTRIFUGAL HVAC FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Backward-inclined centrifugal fans.

1.3 PERFORMANCE REQUIREMENTS

- A. Project Altitude: Base fan performance ratings on actual Project site elevations above sea level.
- B. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
 - 1. Certified fan performance curves with system operating conditions indicated.
 - 2. Certified fan sound-power ratings.
 - 3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 4. Material thickness and finishes, including color charts.
 - 5. Dampers, including housings, linkages, and operators.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
 - 2. Design Calculations: Calculate requirements for selecting vibration isolators and restraints and for designing vibration isolation bases.
 - 3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

- C. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For centrifugal fans to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
- C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA 1.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.
- B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.
- C. Lift and support units with manufacturer's designated lifting or supporting points.

1.7 COORDINATION

- A. Coordinate size and location of structural-steel support members.
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

1.8 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Belts: One set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 IN-LINE CENTRIFUGAL VENTILATING FANS

- A. Furnish and install in-line centrifugal fan with heavy gauge aluminum housing, with removable access panels, providing straight through in-line air flow and fitted with square inlet and outlet duct collars, supports for fan and motor, inlet cone, aluminum backwardly inclined blades, statically and dynamically balanced, and with adjustable V-belt drive as hereinafter specified, stainless steel shaft, stainless steel fasteners, aluminum motor cover, fan and attached accessories coated with Hi-Pro polyester. Bearings shall be selected for minimum L5 life, in excess of 200,000 hours at maximum cataloged operating speed. Motors shall be 60 hertz, A.C. motor as hereinafter scheduled; also refer to Auxiliary Equipment, Paragraph 12. Fans shall be Greenheck Model BSQ, Twin City, Aerovent, Cook, or approved equal.
- B. Schedule of In-Line Centrifugal Fan: Refer to Drawings.

2.2 AUXILIARY EQUIPMENT

- A. Fan Drive: Each new belted fan shall be equipped with a new Texrope, Goodrich, Worthington, or equal, V-belt drive with the sizes and number of belts as rated by the manufacturer of the drives, for the various horsepower transmissions and speeds, plus one additional belt (except on fractional horsepower drives). Sheaves shall be furnished by the fan manufacturer. Sheaves shall be of the pressed steel type, and of the proper pitch diameter for correct fan speed. Motor pulley shall be variable pitch type for partial speed regulation; 10% above and 10% below rated speed.
- B. Belt Guards: For all new V-belt drives, contractor shall furnish and install a new sheet steel or expanded metal guard complying with OSHA requirements to enclose the drive completely and securely fastened with brackets to fan housing or foundation. Guards for centrifugal fans shall be split horizontally to permit removal of the upper half and of ample length for each motor adjustment.
- C. Fan Motors: Furnish and install all driving motors for new fans. Generally, all motors shall be ball bearing, of squirrel cage induction type, and wound for 460 or 200 volt, 3 phase, 60 hertz current; certain motors shall be wound for 115 volt, single phase, 60 hertz; all built in accordance with NEMA standards for 40EC. ambient motors. Each fan motor must be capable of driving the fan to which it is connected for a period of eight hours continuous run, with a rise in temperature of winding and core not exceeding NEMA limits of temperature rise above the temperature of the surrounding atmosphere. Motors shall be open drip proof, high efficiency. Motors shall be General Electric, Louis Allis, Siemens-Allis, U. S. Motor, Marathon, or Reliance-Westinghouse, and belt driven fans shall be mounted on sliding bases.
- D. Machine Bases: Each new centrifugal fan and its driving motor shall be mounted on a common welded steel angle iron or channel base, the depth of which shall be not less than 1/12 of the longest dimension between support points. Base for fans shall be equipped with spring type vibration isolators arranged for and including seismic 2 snubbers; isolators for fans driven at more than 500 RPM by 20 h.p. and smaller

motors shall have a minimum static deflection of 1.75"; isolators for all other fans shall have a minimum static deflection of 2.5". Bids shall be based on isolators of Amber Booth; substitute bids may be submitted on isolators of Kinetics, Korfund, Mason Industries, Vibration Eliminator Co., Vibration Mountings and Controls, Inc., or equal manufacture. All isolators shall be properly proportioned for the load. All centrifugal fans shall be mounted on concrete base provided by the HVAC Contractor.

- E. Flexible Connections: Where suction or discharge of each fan is connected to new galvanized iron ducts or casings, provide an airtight Vent-fab connection to prevent vibration from being transmitted to ductwork. Connection shall be not less than 6" long and shall be securely fastened to fan and ductwork, and shall be airtight.
- F. Motor Controllers: Unless otherwise excepted herein, all other motor controllers will be furnished by the Electrical Contractor.
- G. Lubricating Fittings: Lubricating fittings of approved type shall be provided on all bearings.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install centrifugal fans level and plumb.
- B. Support suspended units from structure using stainless steel threaded steel rods and spring hangers with vertical-limit stops having a static deflection of 1 inch. Vibration-control devices are specified in Division 23 Section "Vibration Controls for HVAC Piping and Equipment."
- C. Install units with clearances for service and maintenance.
- D. Label fans according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories."
- B. Install ducts adjacent to fans to allow service and maintenance.
- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
1. Verify that shipping, blocking, and bracing are removed.
 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 3. Verify that cleaning and adjusting are complete.
 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 5. Adjust belt tension.
 6. Adjust damper linkages for proper damper operation.
 7. Verify lubrication for bearings and other moving parts.
 8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 9. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
 10. Remove and replace malfunctioning units and retest as specified above.
- B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 233416

SECTION 233713 - DIFFUSERS, REGISTERS AND GRILLES

PART 1 - GENERAL

1.1 REFERENCE

A. SCOPE OF WORK

1. Provide diffusers and appurtenances with size and capacities as shown on drawings.

1.2 SUBMITTALS

A. Product Data: For each product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish and mounting details; and performance data including throw and drop, static-pressure drop and noise ratings.
2. Diffuser Schedule: Indicate drawing designation, room location, quantity, model number, size and accessories furnished.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified:

1. Price (Basis of Design)
2. Krueger
3. Titus
4. Anemostat

2.2 SQUARE PLAQUE FACED CEILING DIFFUSERS

- ##### A. Ceiling diffusers of sizes and mounting types designated by the plans and air device schedule. Diffusers shall consist of a precision formed back cone of one piece seamless construction which incorporates a round inlet collar of sufficient length for connecting rigid or flexible duct. An inner plaque assembly shall be incorporated that drops no more than 1/4" below the ceiling plane to assure proper air distribution performance. The inner plaque assembly shall be completely removable from the diffuser face to allow full access to any dampers or other ductwork components located near the diffuser neck. The diffuser is to include an integral opposed blade damper that is adjustable from the face of the air device. Finish shall be white powder coat.

2.3 SOURCE QUALITY CONTROL

- ##### A. Verification of Performance: Rate diffusers, registers and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas where diffusers are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install diffusers and air devices level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw and pressure drop. Make final locations where indicated as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers and air devices with airtight connections to ducts and to allow service and maintenance of dampers, air extractors and fire dampers.

3.3 ADJUSTING

- A. After installation, adjust diffusers and air devices to air patterns indicated, or as directed before starting air balancing.

END OF SECTION 233713

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SECTION 236313 - AIR-COOLED REFRIGERANT CONDENSERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes packaged, air-cooled refrigerant condensers for [outdoor] [indoor] installation.

1.3 SUBMITTALS

- A. Product Data: For each air-cooled refrigerant condenser. Include rated capacities, operating characteristics, furnished specialties, and accessories. Include equipment dimensions, weights and structural loads, required clearances, method of field assembly, components, and location and size of each field connection.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Fabricate and label refrigeration system according to ASHRAE 15, "Safety Standard for Refrigeration Systems."
- C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.5 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.
- C. Coordinate location of refrigerant piping and electrical rough-ins.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Carrier.
- B. Trane.
- C. York.
- D. Daiken.

2.2 MANUFACTURED UNITS

- A. Description: Factory assembled and tested; consisting of casing, condenser coils, condenser fans and motors, and unit controls.
- B. Refrigerant: R-407C or R-410A.
- C. Condenser Coil: Factory tested at 425 psig.
 - 1. Tube: 1/2-inch-diameter seamless copper.
 - 2. Coil Fin: Aluminum.
 - 3. Coating: Thermoplastic vinyl.
 - 4. Circuit: To match compressors.
- D. Condenser Fans and Drives: Propeller fans with aluminum or galvanized-steel fan blades, for vertical air discharge; directly driven with permanently lubricated ball-bearing motors with integral current- and thermal-overload protection.
 - 1. Weather-proof motors with rain shield and shaft slinger.
 - 2. Extend grease lines to outside of casing.
- E. Operating and Safety Controls: Include condenser fan motor thermal and overload cutouts; 115-V control transformer, if required; magnetic contactors for condenser fan motors and a nonfused factory-mounted and -wired disconnect switch for single external electrical power connection.
 - 1. Fan Cycling Control: Head pressure switches.
- F. Casings: Galvanized or zinc-coated steel treated and finished with manufacturer's standard paint coating, designed for outdoor installation with weather protection for components and controls, and with the following:
 - 1. Removable panels for access to controls, condenser fans, motors, and drives.
 - 2. Stainless-steel fan guards.
 - 3. Lifting eyes.
 - 4. Removable legs, 20 inches high.

2.3 CAPACITIES AND CHARACTERISTICS

- A. Refer to Drawings.

2.4 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - 1. Enclosure Type: Totally enclosed, fan cooled.
 - 2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 3. Mount unit-mounted disconnect switches on exterior of unit.

2.5 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate air-cooled refrigerant condensers according to ARI 460.
- B. Testing Requirements: Factory test sound-power-level ratings according to ARI 270.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of air-cooled refrigerant condensers.
- B. Examine roughing-in for refrigerant piping systems to verify actual locations of piping connections before equipment installation.
- C. Examine walls, floors, and roofs for suitable conditions where air-cooled condensers will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install units level and plumb, firmly anchored in locations indicated; maintain manufacturer's recommended clearances.
- B. Maintain manufacturer's recommended clearances for service and maintenance.
- C. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Refrigerant Piping: Connect piping to unit with pressure relief, service valve, filter-dryer, and moisture indicator on each refrigerant-circuit liquid line. Refrigerant piping and specialties are specified in Section 232300 "Refrigerant Piping."

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
 - 1. Perform electrical test and visual and mechanical inspection.
 - 2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Complete manufacturer's starting checklist.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 5. Verify proper airflow over coils.
- C. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.
- D. Air-cooled refrigerant condensers will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.5 STARTUP SERVICE

- A. Perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - a. Inspect for physical damage to unit casing.
 - b. Verify that access doors move freely and are weathertight.

- c. Clean units and inspect for construction debris.
 - d. Verify that all bolts and screws are tight.
 - e. Adjust vibration isolation and flexible connections.
 - f. Verify that controls are connected and operational.
2. Lubricate bearings on fan motors.
 3. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.
 4. Adjust fan belts to proper alignment and tension.
 5. Start unit according to manufacturer's written instructions and complete manufacturer's startup checklist.
 6. Measure and record airflow and air temperature rise over coils.
 7. Verify proper operation of capacity control device.
 8. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.
 9. After startup and performance test, lubricate bearings.

3.6 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain air-cooled refrigerant condensers.

END OF SECTION 236313

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SECTION 237314 – VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Sections
 - 1. 232123 – Hydronic Pumps
 - 2. 233423 – HVAC Fans

1.2 DESCRIPTION OF WORK

- A. Furnish the new variable frequency drives of NEMA type 1 construction as hereinafter specified and consisting of the following principal essentials.
- B. All variable frequency drives to be furnished with an integral disconnect.
- C. The start-up of the variable frequency drives shall be performed by the manufacturer, the cost of which shall be included in his proposal. All details of construction and installation shall meet the approval of the Engineer. In addition, manufacturer shall provide the operating instruction manuals and a total of four (4) hours of instruction and training on the operation of the variable frequency drives.
- D. The equipment shall comply with the specification, shall be the product of a reputable manufacturer, and shall operate at the manufacturers standard ratings in all respects. All parts shall be suited to the service and not subject to injury under any condition that may occur in the normal operation of the system.
- E. The variable frequency drives shall be compatible with any standard NEMA design B, premium efficiency, 1.15 SF, Class H insulation, three phase induction motor.
- F. The entire installation shall comply with all state and local laws, and the National Electrical Code.

1.3 SUMMARY

- A. Includes separately enclosed, pre-assembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.4 DEFINITIONS

- A. AHU: Air Handling Unit
- B. BAS: Building automation system.
- C. CPT: Control power transformer.
- D. EMI: Electromagnetic interference.
- E. IGBT: Insulated-gate bipolar transistor.
- F. LAN: Local area network.
- G. LED: Light-emitting diode.
- H. MCP: Motor-circuit protector.
- I. NC: Normally closed.
- J. NO: Normally open.
- K. OCPD: Overcurrent protective device.
- L. PCC: Point of common coupling.
- M. PID: Control action, proportional plus integral plus derivative.
- N. PWM: Pulse-width modulated.
- O. RFI: Radio-frequency interference.
- P. TDD: Total demand (harmonic current) distortion.
- Q. THD(V): Total harmonic voltage demand.
- R. VFC: Variable-frequency motor controller (drive).

1.5 SUBMITTALS

- A. Product Data: For each type and rating of VFC indicated. Include features, performance, electrical ratings, operating characteristics, shipping and operating weights, and furnished specialties and accessories.
- B. Shop Drawings: For each VFC indicated. Include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.
 - 1. Show tabulations of installed devices, equipment features, and ratings. Include the following:

- a. Each installed unit's type and details.
 - b. Factory-installed devices.
 - c. Enclosure types and details.
 - d. Nameplate legends.
 - e. Short-circuit current (withstand) rating of enclosed unit.
 - f. Features, characteristics, ratings, and factory settings of each VFC and installed devices.
2. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring.
- C. Product Certificates: For each VFC, from manufacturer.
 - D. Source quality-control reports.
 - E. Field quality-control reports.
 - F. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals. Include the following:
 1. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and MCP trip settings.
 2. Manufacturer's written instructions for setting field-adjustable overload relays.
 3. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
 4. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
 - G. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.
 - H. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.
- 1.6 QUALITY ASSURANCE
- A. Testing Agency Qualifications: Member company of NETA or an NRTL.
 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
 - B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - C. Comply with NFPA 70.

- D. IEEE Compliance: Fabricate and test VFC according to IEEE 344 to withstand seismic forces.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store VFC's indoors to clean, dry space with uniform temperature to prevent condensation. Protect VFC's from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.8 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions unless otherwise indicated:
 - 1. Ambient Temperature: Not less than 14 deg F and not exceeding 104 deg F.
 - 2. Ambient Storage Temperature: Not less than minus 4 deg F and not exceeding 140 deg F.
 - 3. Humidity: Less than 95 percent (noncondensing).
 - 4. Altitude: Not exceeding 3300 feet.

1.9 COORDINATION

- A. Coordinate features of motors, load characteristics, installed units, and accessory devices to be compatible with the following:
 - 1. Torque, speed, and horsepower requirements of the load.
 - 2. Ratings and characteristics of supply circuit and required control sequence.
 - 3. Ambient and environmental conditions of installation location.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

1.10 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

1.11 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: two of each type and color installed.
4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 1. ABB – Series ACH 550.
 2. Yaskawa Electric America, Inc.; Drives Division.
- B. General Requirements for VFCs: Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.

2.2 VARIABLE FREQUENCY MOTOR CONTROLLERS (DRIVES)

- A. Provide drives as scheduled.
- B. Each variable speed drive package shall consist of a non-fusible disconnect switch, a non-fusible disconnect service switch, control power supply, fuses, relays and terminals, all installed in a single standardized NEMA type 1 enclosure.
- C. A disconnect shall be provided in the incoming line of each VFC package and shall consist of a 600 volt A.C. 3 pole non-fusible disconnect switch with quick-make, quick-break mechanism. The operating handle of each disconnect shall clearly indicate whether the switch is Δ ON or "OFF". External operating handle shall be equipped with provision for locking disconnect in "OFF" position.
- D. Variable Frequency Drive
 1. The variable frequency drive controller shall be microprocessor based, fully transistorized pulse width modulated (PWM) design producing a sine-coded output waveform. The output transistors shall be of insulated gate bipolar transistors (IGBT) with soft switching technology to facilitate noiseless motor operation and improved reliability.
 2. The variable frequency drive controller shall be equipped with a graphic back-lit liquid crystal display (LCD) and keypad which can be configured to display, output frequency, current, set points, VFC status and fault codes, BACNET card, etc.

3. Operating features:

- a. Linear speed control from 0% to 100% of maximum speed.
- b. The variable frequency drive shall be able to withstand input voltage variations of 15% below and 10% above 460 volt 3 phase nominal, and imbalance no greater than 3% without tripping or adversely affecting drive performance.
- c. The displacement power factor of the variable frequency drive shall be 95% lagging or higher for all speeds.
- d. Drive efficiency at rated load shall be 95% or higher.
- e. "Speed search" transfer: Drive shall have the ability to automatically start into a spinning motor without stopping the motor or creating a fault condition.
- f. Auto restart: programmable "intelligent" auto restart precludes any attempt at restart in the event of trips typically indicative of component failure. Programmable for up to ten (10) restarts.
- g. Minimum of two second power loss ride-through capability. In the event of a loss of power lasting two seconds or less the drive shall maintain operation and prevent nuisance trips upon return of power. In the event of a loss of power lasting more than two seconds, the auto restart function shall restart drive.
- h. Output three phase current sensing class 20 overload relay to provide motor protection.
- i. Carrier frequency: 1 to 12KHZ
- j. Acceleration and deceleration settings: 0.1 to 1800 seconds, using three modes (linear, S-curve, non-linear).
- k. System Control interfaces: The variable frequency drive shall be set up to accept control signals from the campus DDC system through the drives standard embedded fieldbus (EFB) using standard BAC net protocol.
- l. 24 volt DC level commands for remote digital inputs to drive to indicate:
 - 1) Start/Stop
 - 2) Control (Preset) Speed 1
 - 3) Safety Interlock
- m. 230 volt AC rated contacts for remote indication of VFD status.
 - 1) VFD ready
 - 2) VFD run
 - 3) VFD fault
- n. Remote serial control: Each VFD shall be equipped with standard BAC net communication interface protocol for connection to the DDC system to integrate VFD specific parameters into the system such as operating characteristics (current, voltage, frequency) and inverter faults. A separate RS-232 port shall be provided for connection to an external PC for troubleshooting purposes without interrupting the operation of the RS-485 link.

- E. All variable frequency drives shall be equipped with a keypad/annunciator panel to show all HVAC specific data for intuitive, convenient operation by building personnel. Annunciator shall include the following:
 - 1. A single-line diagram of power circuit with LED indicators for status of each of the following components:
 - a. Ready
 - b. Enable
 - c. Output contactor
 - d. VFD run
 - 2. LED indicators for status of the following alarm conditions:
 - a. Automatic transfer
 - b. VFD fault
 - 3. Individual keypad pushbuttons and LED indicators for the following:
 - a. VFD drive select
 - b. VFD reset
 - c. VFD auto
 - d. VFD off
 - e. VFD hand
- F. Nameplates
 - 1. On the front of each variable frequency drive, provide suitable black plastic nameplate with white cut letters. Abbreviations will not be permitted unless authorized by the Engineer.
- G. Schedule Of Variable Frequency Drives
 - 1. Refer to Drawings.

2.3 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.
 - 1. Test each VFC while connected to a motor that is comparable to that for which the VFC is rated.
 - 2. Verification of Performance: Rate VFCs according to operation of functions and features specified.
- B. VFCs will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Coordinate the following examination procedures with the HVAC Contractor.
- B. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance.
- C. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.
- D. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Coordinate the following installation procedures with the HVAC Contractor.
- B. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- C. Wall-Mounting Controllers: Install VFCs on walls with tops at uniform height and with disconnect operating handles not higher than 79 inches (2000 mm) above finished floor unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall.
- D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- E. Install fuses in each fusible-switch VFC.
- F. Install fuses in control circuits if not factory installed. Comply with requirements in Division 26 Section "Fuses."
- G. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.
- H. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
- I. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Assist the HVAC Contractor with the following identification procedures.
- B. Identify VFCs, components, and control wiring.
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each VFC with engraved nameplate.
 - 3. Label each enclosure-mounted control and pilot device.
- C. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.4 CONTROL WIRING INSTALLATION

- A. Assist the HVAC Contractor with the following control wiring installation procedures.
- B. Install wiring between VFCs and remote devices and facility's central-control system.
- C. Bundle, train, and support wiring in enclosures.
- D. Connect selector switches and other automatic control devices where applicable.
 - 1. Connect selector switches to bypass only those manual- and automatic control devices that have no safety functions when switches are in manual-control position.
 - 2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.5 FIELD QUALITY CONTROL

- A. Assist the HVAC Contractor with the following field quality control procedures.
- B. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Provide a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- D. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Provide factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- E. Acceptance Testing Preparation:

1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

F. Tests and Inspections:

1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Engineer and Commissioning Agent before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

G. VFCs will be considered defective if they do not pass tests and inspections.

H. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 STARTUP SERVICE

- A. Provide a factory-authorized service representative to perform startup service.
1. Complete installation and startup checks according to manufacturer's written instructions.

3.7 ADJUSTING

- A. Assist the HVAC Contractor with the following adjustment procedures.
- B. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.
- C. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
- D. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load

amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Engineer and Commissioning Agent before increasing settings.

- E. Set the taps on reduced-voltage autotransformer controllers.
- F. Set field-adjustable pressure switches.

3.8 PROTECTION

- A. Assist the HVAC Contractor with the following protection procedures.
- B. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.
- C. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.9 DEMONSTRATION

- A. Provide a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs. Video training sessions. Provide a minimum of 4 hours of training for Owner's personnel.

END OF SECTION 237314

SECTION 238216 - REFRIGERANT AIR COILS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes refrigerant air coils.

1.3 SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
 - 2. Include rated capacities, operating characteristics, and pressure drops for each air coil.
- B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which coil location and ceiling-mounted access panels are shown and coordinated with each other.
- C. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 DESCRIPTION

- A. ASHRAE Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

2.2 REFRIGERANT AIR COILS

- A. Manufacturers:
 - 1. Carrier Corporation.
 - 2. Marlo Coil; Subsidiary of Engineered Support Systems, Inc.
 - 3. McQuay International.
 - 4. Trane.

5. YORK International Corporation.
 - B. Performance Ratings: Tested and rated according to AHRI 410 and ASHRAE 33.
 - C. Minimum Working-Pressure Rating: 300 psig.
 - D. Source Quality Control: Factory tested to 450 psig.
 - E. Tubes: ASTM B 743 copper, minimum 0.035 inch thick.
 - F. Fins: Aluminum, minimum 0.010 inch thick.
 - G. Suction and Distributor Piping: ASTM B 88, Type L copper tube with brazed joints.
 - H. Frames: Galvanized-steel channel frame, minimum 0.052 inch thick for slip-in mounting.
 - I. Frames: ASTM A 666, Type 304 stainless steel, minimum 0.0625 inch thick for slip-in mounting.
 - J. Capacities and Characteristics:
 1. Refer to Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install coils level and plumb.
- B. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
- C. Install galvanized-steel drain pan under each cooling coil.
 1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
 2. Construct drain pans to extend beyond coil length and width and to connect to condensate trap and drainage.

3. Extend drain pan upstream and downstream from coil face.
 4. Extend drain pan under coil headers and exposed supply piping.
- D. Install moisture eliminators for cooling coils. Extend drain pan under moisture eliminator.
 - E. Straighten bent fins on air coils.
 - F. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to coils to allow service and maintenance.
- C. Connect refrigerant piping according to Section 232300 "Refrigerant Piping."

END OF SECTION 238216

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SECTION 238219 - FAN COIL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Concealed fan coil units and accessories.
 - 2. Ducted fan coil units and accessories.

1.3 SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
- B. Shop Drawings:
 - 1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Include diagrams for power, signal, and control wiring.
- C. Samples for Initial Selection: For units with factory-applied color finishes.
- D. Samples for Verification: For each type of fan coil unit indicated.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fan Coil Unit Filters: Furnish one (1) spare filters for each filter installed.

1.5 QUALITY ASSURANCE

- A. Comply with NFPA 70.

- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.6 COORDINATION

- A. Coordinate layout and installation of fan coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.
- B. Coordinate size and location of wall sleeves for outdoor-air intake.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Compressor failure.
 - b. Condenser coil leak.
 - 2. Warranty Period: Five years from date of Substantial Completion.
 - 3. Warranty Period (Compressor Only): Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Manufacturers:
 - 1. Carrier Corporation.
 - 2. Marlo Coil; Subsidiary of Engineered Support Systems, Inc.
 - 3. McQuay International.
 - 4. Trane.
 - 5. YORK International Corporation.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Factory-packaged and -tested units rated according to AHRI 440, ASHRAE 33, and UL 1995.

2.2 CONCEALED FAN COIL UNITS

- A. Fan Coil Unit Configurations:
 - 1. Number of Coils: One with two-pipe system.
- B. Coil Section Insulation: 1/2-inch-thick, coated glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
 - 1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
 - 2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- C. Coil Section Insulation: Insulate coil section according to Section 230616 "HVAC Equipment Insulation."
 - 1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
 - 2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Main and Auxiliary Drain Pans: Insulated galvanized steel with plastic liner. Fabricate pans and drain connections to comply with ASHRAE 62.1. Drain pans shall be removable.
- E. Chassis: Galvanized steel where exposed to moisture, with baked-enamel finish and removable access panel. Floor-mounting units shall have leveling screws.
- F. Cabinet: Steel with factory prime coating, ready for field painting.
 - 1. Vertical Unit Front Panels: Removable, steel, with top outlet duct flange.
- G. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.
 - 1. MERV Rating: 6 when tested according to ASHRAE 52.2.
- H. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.
- I. Fan and Motor Board: Removable.
 - 1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.

2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
 3. Wiring Termination: Connect motor to chassis wiring with plug connection.
- J. Factory, Hydronic Piping Package: ASTM B 88, Type L copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
1. Two-way, modulating control valve for dual-temperature coil.
 2. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.
 3. Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125-psig working pressure, 250 deg F maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and a memory stop to retain set position.
 4. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 hose-end, full-port, ball-type blowdown valve in drain connection.
 5. Wrought-Copper Unions: ASME B16.22.
 6. Risers: ASTM B 88, Type L copper pipe with hose and ball valve for system flushing.
- K. ACCESSORIES
1. Control equipment and sequence of operation are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."
 2. HVAC Contractor to provide integral disconnect switch with Fan Coil Units.
- L. Basic Unit Controls:
1. Control voltage transformer.
 2. Unit-mounted thermostat with the following features:
 - a. Heat-cool-off switch.
 - b. Fan on-auto switch.
 - c. Fan-speed switch.
 - d. Adjustable deadband.
 - e. Exposed set point.
 - f. Exposed indication.
 - g. Degree F indication.
- M. DDC Terminal Controller:
1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
 2. Unoccupied-Period-Override Operation: Two hours.
 3. Unit Supply-Air Fan Operation:

- a. Occupied Periods: Fan runs continuously.
 - b. Unoccupied Periods: Fan cycles to maintain room setback temperature.
4. Dual-Temperature Hydronic-Coil Operation:
- a. Occupied Periods: When chilled water is available, modulate control valve if room temperature exceeds thermostat set point. When hot water is available, open control valve if temperature falls below thermostat set point.
 - b. Unoccupied Periods: When chilled water is available, control valve if room temperature exceeds thermostat set point. When hot water is available, modulate control valve if room temperature falls below thermostat setback temperature.
- N. Interface with DDC System for HVAC Requirements:
1. Interface relay for scheduled operation.
 2. Interface relay to provide indication of fault at the central workstation.
 3. Provide BACnet interface for central DDC system for HVAC workstation for the following functions:
 - a. Adjust set points.
 - b. Fan coil unit start, stop, and operating status.
 - c. Data inquiry, including supply- and room-air temperature.
 - d. Occupied and unoccupied schedules.
- O. Electrical Connection: Factory wire motors and controls for a single electrical connection.
- P. Capacities and Characteristics:
1. Refer to Drawings.
- 2.3 DUCTED FAN COIL UNITS
- A. Fan Coil Unit Configurations:
1. Number of Coils: One with two-pipe system.
- B. Coil Section Insulation: 1/2-inch-thick, coated glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
 2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- C. Coil Section Insulation: Insulate coil section according to Section 230616 "HVAC Equipment Insulation."

1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
 2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Main and Auxiliary Drain Pans: Insulated galvanized steel with plastic liner. Fabricate pans and drain connections to comply with ASHRAE 62.1.
- E. Chassis: Galvanized steel where exposed to moisture, with baked-enamel finish and removable access panel. Floor-mounting units shall have leveling screws.
- F. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.
1. Supply-Air Plenum: Sheet metal plenum finished and insulated to match the chassis with mill-finish, aluminum, double-deflection grille.
 2. Return-Air Plenum: Sheet metal plenum finished to match the chassis.
 3. Dampers: Galvanized steel with extruded-vinyl blade seals, flexible-metal jamb seals, and interlocking linkage.
- G. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.
- H. MERV Rating: 6 when tested according to ASHRAE 52.2.
- I. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.
- J. Indoor Refrigerant Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and brazed joints at fittings. Comply with AHRI 210/240, and leak test to minimum 450 psig for a minimum 300-psig working pressure. Include thermal expansion valve.
- K. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.
- L. Belt-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, single-speed motor installed on an adjustable fan base resiliently mounted in the cabinet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.
1. Motors: Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
- M. Factory, Hydronic Piping Package: ASTM B 88, Type L copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
1. Two-way, modulating control valve for dual-temperature coil.

2. Hose Kits: Minimum 400-psig working pressure and operating temperatures from 33 to 211 deg F. Tag hose kits to equipment designations.
 - a. Length: 24 inches.
 - b. Minimum Diameter: Equal to fan coil unit connection size.
 3. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.
 4. Automatic Flow-Control Valve: Brass or ferrous-metal body; 300-psig working pressure at 250 deg F; with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig.
 5. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 hose-end, full-port, ball-type blowdown valve in drain connection.
 6. Wrought-Copper Unions: ASME B16.22.
- N. Remote condensing units are specified in Section 236200 "Packaged Compressor and Condenser Units."
- O. Basic Unit Controls:
1. Control voltage transformer.
 2. Wall-mounting temperature sensor.
 3. Unoccupied-period-override push button.
 4. Data entry and access port.
 - a. Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
 - b. Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.
- P. DDC Terminal Controller:
1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
 2. Unoccupied-Period-Override Operation: Two hours.
 3. Unit Supply-Air Fan Operation:
 - a. Occupied Periods: Fan runs continuously.
 - b. Unoccupied Periods: Fan cycles to maintain room setback temperature.
 4. Hydronic-Cooling-Coil Operation:
 - a. Occupied Periods: Modulate control valve to maintain room temperature.
 - b. Unoccupied Periods: Close control valve.
 5. Refrigerant-Coil Operation:

- a. Occupied Periods: Start compressor to maintain room temperature or humidistat set point.
 - b. Unoccupied Periods: Stop compressor cooling and cycle compressor for heating to maintain setback temperature.
6. Dual-Temperature Hydronic-Coil Operation:
- a. Occupied Periods: When chilled water is available, modulate control valve if room temperature exceeds thermostat set point. When hot water is available, modulate control valve if temperature falls below thermostat set point.
 - b. Unoccupied Periods: When chilled water is available, close valve. When hot water is available, modulate control valve if room temperature falls below thermostat setback temperature.
7. Controller shall have volatile-memory backup.
- Q. Interface with DDC System for HVAC Requirements:
1. Interface relay for scheduled operation.
 2. Interface relay to provide indication of fault at the central workstation.
 3. Provide BACnet interface for central DDC system for HVAC workstation for the following functions:
 - a. Adjust set points.
 - b. Fan coil unit start, stop, and operating status.
 - c. Data inquiry, including supply- and room-air temperature.
 - d. Occupied and unoccupied schedules.
- R. Electrical Connection: Factory wire motors and controls for a single electrical connection.
- S. HVAC Contractor to provide integral disconnect with Fan Coil Units.
- T. Capacities and Characteristics:
1. Refer to Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, with Installer present, to receive fan coil units for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before fan coil unit installation.

- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install fan coil units level and plumb.
- B. Install fan coil units to comply with NFPA 90A.
- C. Suspend fan coil units from structure with elastomeric hangers.
- D. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above finished floor.
- E. Install new filters in each fan coil unit within two weeks after Substantial Completion.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
 - 1. Install piping adjacent to machine to allow service and maintenance.
 - 2. Connect piping to fan coil unit factory hydronic piping package. Install piping package if shipped loose.
 - 3. Connect condensate drain to indirect waste.
 - a. Install condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.
- B. Connect supply-air and return-air ducts to fan coil units with flexible duct connectors specified in Section 233300 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.
- C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 - 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain fan coil units.

END OF SECTION 238219

SECTION 250000 – INTEGRATED AUTOMATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes a summary of all Integrated Automation which is principally Direct Digital Control (DDC System) related work.

- B. Related Sections:

- 1. 250501 – COMMON WORK RESULTS FOR INTEGRATED AUTOMATION
 - 2. 250990 – SEQUENCE OF OPERATION

- C. Work by Others:

- 1. The following work will be done by other contractors, as specified under respective headings, which this contractor shall read to ascertain what is called for therein:
 - a. HVAC
 - b. Electric
 - 2. The Integrated Automation Work shall be a subcontract to the HVAC Contractor.

1.3 GENERAL

- A. This contract shall include the furnishing of all labor and materials required for the installation of new temperature regulating systems to monitor, control, and regulate automatically and completely the new chiller, as shown on the accompanying drawings and hereinafter specified. The temperature control equipment shall be installed by trained mechanics and technicians employed by the manufacturer and working in conjunction with the other contractors.
- B. Bids for the temperature control work, hereinafter specified, shall be based upon a Siemens direct digital control system with electronic sensors for indication and control functions, electrically actuated devices including new valves, etc., and all connections to sensors and actuated devices. All bidders of controls shall comply with this specification and shall provide any additional labor, hardware, software, programming, network integrators, etc., to communicate with, control and display graphically the new systems.
- C. Provide a complete, neat and workmanlike installation. Use only manufacturer employees who are skilled, experienced, trained, and familiar with the specific equipment, software, standards and configurations to be provided for this project.

- D. The BMS as provided shall incorporate, at minimum, the following integrated features, functions and services:
 - 1. Operator information, alarm management and control functions.
 - 2. Enterprise-level information and control access.
 - 3. Information management including monitoring, transmission, archiving, retrieval, and reporting functions.
 - 4. Diagnostic monitoring and reporting of BMS functions.
 - 5. Offsite monitoring and management access.
 - 6. Energy management.
 - 7. Standard applications for terminal HVAC systems.
- E. Acceptable Manufacturers and Installers:
 - 1. Siemens Controls.
- F. The BMS Contractor shall be a recognized national manufacturer, installer and service provider of BMS. The BMS Contractor shall have a branch facility within a 50-mile radius of the job site supplying complete maintenance and support services on a 24 hour, 7-day-a-week basis.
- G. The Building Management System architecture shall consist of the products of a manufacturer regularly engaged in the production of Building Management Systems, and shall be the manufacturer's latest standard of design at the time of bid.
- H. The new systems shall be complete with all piping connections, switches, relays, wiring, or other devices required to accomplish the required results. All control devices shall be of the manufacturer's best construction. Complete shop drawings of the control system shall be submitted for approval. Contractor shall become thoroughly familiar with interconnections, with equipment specified under other sections of this specification including electric work, and all work furnished by the Direct Digital Control Contractor shall be coordinated therewith.

1.4 PROJECT CONDITIONS

- A. Alterations and Additions to DDC Systems
 - 1. The contract shall include new work as shown, specified, or required, and shall include, but not limited to, the following principle components:
 - a. Provide complete system for control of all equipment and systems as specified herein for Base Bid and Alternate Bids.
 - b. Furnish and install all requisite wells and devices for temperature, pressure, alarm, indication, etc.
- B. Shop Drawings
 - 1. As soon as possible after award of the contract, and prior to fabrication, the contractor shall prepare complete shop drawings of the DDC systems, which shall in general conform to the bidding documents; any deviations deemed necessary by the contractor shall be noted and agreed upon prior to starting the work.
 - 2. In preparing his working drawings, the contractor shall coordinate the location of all equipment and devices with the other contractors. Drawings shall show ceiling grids, lights, registers, grilles, heat detection devices, access panel, skylights, etc. Any

changes in fabricated DDC layout occasioned by lack of coordination shall be made by the contractor at no change in the contract price.

3. Drawing shall be on 11" x 17" or 18" x 24" sheets at the contractor's option.
4. All submittals shall be in PDF format and routed through the Engineer.
5. The submittals shall include control diagrams of all equipment that is to be controlled, monitored, etc. The submittal shall include all of the control information for chiller, variable frequency drives, etc.
6. The contractor shall implement all control sequences specified and indicated on the input/output schedules.
7. Each input/output device shall have a unique identifier which shall be permanently labeled on or adjacent to the device. The unique identifier shall be labeled on the various submittals as well.

C. Restoration Of Surfaces

1. Refer to Division 01.

D. Guarantee

1. This contractor shall guarantee all workmanship, materials, and equipment entering into this contract for a period of two years; all from date of substantial completion or from the "recognized" start-up date, whichever is later. Should the Owner elect to accept a portion of work prior to the date of substantial completion, the guarantee period for the accepted portion of the work shall commence on the date of acceptance or on the "recognized" start-up date for that portion of the work, whichever is later. If the specifications dictate a different period of guarantee for a given component or piece of equipment, the more stringent requirements shall govern.
2. The "recognized" start-up date shall be defined as that date on which the contractor has successfully completed all phases of his work, including the following:
 - a. Submitted and received approval of three (3) copies of the Instruction Booklets.
 - b. Submitted complete "As-Built" drawings.
 - c. Completed all testing, cleaning, adjusting, and trial run. This testing shall include the successful completion of all commissioning tasks.
3. In the case where the Engineer is accepting a portion of the work, the contractor shall have completed all phases of that portion of the work to be accepted, including Items above, for that accepted portion of the work.
4. Any workmanship, materials, or equipment proving to be defective during this guarantee period shall be made good by this contractor without additional cost to the Owner.

E. Equipment

1. Any and all costs associated with piping, electric, wiring, conduit, supports, pads, or other modifications to accommodate installation for manufacturer's equipment that differs from equipment layout on drawings shall be included on contractor's bid. The contractor is responsible to insure that the equipment will fit within space allocated with appropriate clearances for maintenance, operation, servicing, and code.

F. Schedule

1. The contractor shall be responsible to meet the project schedule as stated by the Owner. The contractor shall include in his bid the cost associated with all requisite coordination.

2. In addition, the contractor must prepare a schedule for his work that integrates with the Mechanical Contractor's schedule. The contractor shall update progress and revise schedule at least twice monthly.
3. This contractor shall be responsible to expedite any materials and work any overtime in order to meet the schedule. The cost for any expediting of overtime work shall be included in his bid.
4. Refer to Section 23 00 00 for a detailed project schedule.

1.5 FUNCTIONAL PERFORMANCE TEST

- A. The Functional Performance test (FPT) shall be executed by the Contractor and approved by the Owner. If the project is phased, then a separate test plan shall be executed for each phase. Use FPT sample procedures, designated by the Commissioning Agent, as a guide to creating the test plan spreadsheets.
- B. Obtain written approval of the Functional Performance Test plan for each phase of testing before beginning that phase of testing. Give the Commissioning Agent written notification of planned testing at least 30 days prior to the test but not before completion of any test and balance (TAB) requirements have been completed. Notification shall be accompanied by the proposed test procedure, a verified Pre-performance Testing Checklist, and a written estimated time table required to perform the test. After the written notification is received, the Commissioning Agent shall convene a meeting with the Contractor and the Owner at least 14 days prior to testing. In no case will the Contractor be allowed to start testing without written Owner approval of the Functional Performance Test plan.
- C. Demonstrate compliance of the heating, ventilating, and air conditioning control system with the contract documents including proper labeling of controls and wiring. Furnish personnel, equipment, instrumentation, and supplies necessary to perform calibration and site testing. Ensure that test personnel are regularly employed in the testing and calibration of DDC systems.
- D. Functional Performance testing will include, but not be limited to, workstation operations, calibration results for input and output devices required by manufacturer, proper tuning of control loops, and ensuring proper execution of the sequence of operation. Use the BACnet protocol analyzer during the performance testing to demonstrate communications reliability.
- E. The Pre-performance Testing Checklist shall be used as the Contractor's guide to prepare for the FPT and to guide discussions at the pre-performance test meeting between the Contractor and the Owner. Every item on the check list shall be validated by the Contractor's QC representative prior to the test meeting.
- F. Verify all workstations, notebook computers, and maintenance personnel interface tools have been delivered, all system and database software installed, and graphic pages created for each workstation and notebook computers. Notify the Owner when phone lines or network connections are needed at least 30 days prior to installation of the workstation.
 1. Verify integrity/safety of all electrical connections.
 2. Verify proper communications over network segments and between controllers.
 3. Co-ordinate with TAB contractor to obtain control settings that are determined from balancing procedures.
 4. Test, calibrate, and set all digital and analog sensing and actuating devices as required.
 5. Check and set zero and span adjustments for all actuating devices as required.

6. Check each digital controller for stand-alone operation by temporarily removing from the network.
 7. Check proper sequences have been installed and tested.
 8. Check all control loops have been properly tuned.
 9. Check all alarms are programmed and routed to their proper destination.
 10. Check all trends are operating for each item marked for trending on the points list.
 11. Check all schedules are operating for each item marked for schedules on the points list.
 12. Complete all "as-built" record drawings and I/O points list.
- G. The test procedure reporting documents shall be developed by the Contractor and based specifically on the control system installed in a spread sheet format allowing sufficient space for individual testing of each area of the control system. List the test procedure and the expected response for each piece of equipment and system in each test area specified. Develop a separate row or column for each item that is required to be "demonstrated" within a test area. Allow ample space for comments, pass, fail, and retest lines. Each area of testing shall have four signature lines, one for the Contractor's QC representative, the Contractor's FPT administrator, the Commissioning Agent representative, and the Owner to acknowledge successful completion for each test area. Include references to the paragraph number or drawing number in the contract documents for each item or group of items to be tested. BACnet protocol analyzer test results shall be included with the test reporting. During and after completion of the Functional Performance Test, identify, determine causes, replace, repair or calibrate equipment that fails to meet the specification, and submit a written report to the Owner.
- H. Document all tests with detailed test results. Explain in detail the nature of each failure and corrective action taken. Provide a written report containing test documentation after the Functional Performance Test. Schedule a meeting with the Owner to present the results to the Owner after all failures have been corrected. Based on the report and test review meeting, the Owner will determine the successful completion of the testing. If retesting of any portion of the FPT is required, do not retest until after receipt of written notification by the Owner. At the conclusion of retest, assessment will be repeated. The Owner reserves the right to require retesting of 100 percent on every component in the system when results from sampled areas are found deficient. Final test results will be submitted in electronic format on CD media.
- I. Using the completed shop drawings and the FPT spreadsheet, conduct the performance verification test to demonstrate workstations and network communications are operating correctly, control system maintains set points, control loops are tuned, and controllers are programmed for the correct sequence of operation. The test report shall include the required four authorization signatures for successful completion of each test area. Test areas may have several sub-areas and each shall be fully satisfied to receive approval. Specifically the FPT consists of the individual test areas below and shall demonstrate the following:
- J. Controller Capability, Accessibility, and Labeling
1. Memory: Demonstrate that programmed data, parameters, and trend/alarm history collected during normal operation is not lost due to power failures.
 2. Direct Connect Interface: Demonstrate the ability to connect directly to each type of digital controller with a notebook computer. Demonstrate that maintenance personnel interface tools perform as specified in the Manufacturer's technical literature.
 3. Wiring and AC Power: Demonstrate the ability to disconnect any controller safely from its power source using the AC Power Table.

4. Demonstrate the ability to match wiring labels easily with the control drawings. Demonstrate the ability to locate a controller's location using the riser communications diagram in the control drawings.
5. Nameplates and Tags: Demonstrate the nameplates and tags bearing device unique identifiers are accurate and permanently attached to HVAC the control panel doors and back plates. Demonstrate that plastic or metal tags have the correct equipment name and point identifier.

K. Workstation and Software Operation

1. For operators workstation (OWS) and notebook computer provided:
 - a. Verify that the correct software has been installed and licensed with the latest revisions available, delivery of all associated peripheral components are installed correctly, CD installation media including system restore disks are delivered, and the on-site warranty has been properly registered with the manufacturer. For each existing user workstation or notebook computer specified for upgrade, verify that all hardware and software upgrades have been installed and licensed correctly.
 - b. Demonstrate that point's lists are generated as specified and conform to the proper naming conventions.
 - c. Demonstrate that graphics are complete, resolution size fills the workstation or notebook computer screen areas without scrolling and the operator can navigate successfully to every mechanical system and zone.
 - d. Demonstrate the UPS backup maintains power for the specified time on the workstation during a power failure and can recover automatically after an extended power loss when the UPS battery has drained.
2. BACnet Communications and Interoperability Areas
 - a. Demonstrate proper functioning of the five interoperability areas of data sharing, alarm and event management, trending, scheduling, and device and network management. Use the BACnet protocol analyzer to demonstrate that communications are free from errors and that devices from different manufacturers are interoperable. These requirements shall be met even if there is only one manufacturer's equipment installed.
3. If system can only be programmed at the operator workstation, then two of these workstations shall be provided and included in the base bid.

L. Data Sharing

1. Data Presentation - On each web server workstation, demonstrate graphic display capabilities as follows: Each graphic page shall initially display with current data within 5 seconds over a web-based browser connection and 15 seconds after a dial-up modem connection is established. Updated information shall occur when a change of value (COV) notification is received or, if COV is not implemented, within 15 seconds. Demonstrate that any data value from any networked device shall be available for plotting at a workstation in real time. Select binary and analog data concurrently and plot multiple instances of each data type on the same screen. Demonstrate the ability to select sampling intervals from 10 seconds to 60 minutes. For devices that implement COV reporting, select this as the means to update the plot.
2. Monitoring of Any Property - Demonstrate the ability to display any value of any property of any object from any networked device including all properties required by BACnet, all supported optional properties, and any proprietary extensions. Compare

the difference between properties shown on the operator workstation over the network and the properties shown when directly connected to the controller in the field.

3. Set point and Parameter Modifications - Demonstrate the ability to modify all control loop set points and tuning parameters via BACnet messages initiated through operator interaction with graphics displays. Compare the difference between parameters modified on the operator workstation over the network and the parameters modified when directly connected to the controller in the field.
4. Peer-to-Peer Data Dependencies - Demonstrate all BACnet devices are installed and configured to exchange data values directly, without the need for operator or workstation intervention, to implement the sequence of operations specified in the mechanical system drawings and to share global data values.

M. Alarm and Event Management

1. Alarm Lists - Demonstrate that alarms are installed and configured to detect alarms and events for the points indicated in the system drawings and are prioritized according to the standardized list designated by the Owner. Demonstrate system alarms, such as offline controllers are generated. Demonstrate software logic has been set up to avoid nuisance alarms, e.g., no temperature or status alarms shall be generated when fan systems are not running, or during start-up and shut-down transitions. Demonstrate that delays between the occurrence of an alarm condition and its annunciation are adjustable. Demonstrate alarms appear at any local workstation within 5 seconds over a web-based browser connection and 15 seconds on a dial-up modem connection. Demonstrate workstations display an alarm message window that appears on top of any other open windows and alarm message window has a distinctive color and appearance to attract the operator's attention. Demonstrate alarms that require operator acknowledgment and cause the alarm window to remain active until such an acknowledgment is received and when multiple alarms are received, unacknowledged alarms shall be displayed on a first-come first-served basis grouped by priority, with the highest priority alarms displayed first.
2. Alarm Parameter Adjustment - Demonstrate the ability for operators (with sufficient privilege) to change alarm parameters for all standard BACnet event types.
3. Alarm Routing Adjustment - Demonstrate the ability for operators (with sufficient privilege) to change alarm routing (BACnet notification classes) for each alarm including the destination for each type of alarm and alarm priority, the day of week and time of day, and the type of transition involved (TO-OFFNORMAL, TO-NORMAL, etc.).

N. Scheduling

1. Schedule Lists - Demonstrate that schedules are installed and configured start/stop, mode change, and night setback schedules as defined in the sequence of operations including holidays. Demonstrate the ability to program alterations to programmed operating schedules based on the priority of events, including the ability to temporarily override the programmed schedule of equipment. Demonstrate operational override of a programmed schedule shall be for a specific duration following which the schedule shall revert back to the preprogrammed schedule.
2. Display of Start/Stop Times and Actions - Demonstrate the ability to inspect the content of any schedule and determine the specific control actions that will occur at any time, on any date.
3. Modification of Schedules - Demonstrate that all calendar entries and schedules shall be modifiable from any local workstation by an operator with sufficient privilege.

O. Trending

1. Archival Storage of Data - Demonstrate that archival storage of data will be handled by the operator workstation/server. Demonstrate that local trend archiving and display can be accomplished through the use of BACnet Trend Log objects.
 2. Modification of Trend Log Parameters - Demonstrate that an operator with sufficient privilege shall be able to change the data points to be logged, the sampling rate, and the duration of a trend log.
- P. Device and Network Management
1. Display of Device Status Information - Operators shall be able to display at any time the operational status of any device on the network.
 2. Display of BACnet Object Information - Operators shall be able to display at any time any property of any BACnet object. Operators shall be able to display property values of objects grouped by object type, object location, and building system.
 3. Silencing Devices that are Transmitting Erroneous Data - Operators shall be able to direct a field device to stop transmitting event, alarm, or COV notifications until a subsequent command to resume transmissions is received.
 4. Time Synchronization - Operators shall be able to set the time and date in any device on the network that supports time-of-day functionality. The operator shall be able to select to set the time and date for an individual device or all devices on a single local network.
 5. Remote Device Re-initialization - Operators shall have the ability to issue re-initialization commands to any device that supports remote reinitialization.
 6. Backup and Restore - Operators shall have the ability to backup and restore all BACnet devices on the network that support this capability.
- Q. Execution of Sequence of Operation - Demonstrate the HVAC system operates properly through the complete sequence of operation. Insert the complete sequence of operation into the PVT spreadsheet with spaces between each line to allow for observations and comments.
- R. Control Loop Stability and Accuracy - Furnish the Owner graphed trends of control loops to demonstrate the control loop is stable and that setpoint is maintained. Control loop response shall respond to setpoint changes of 10 percent and stabilize in 3 minutes or less. Control loop trend data shall be in real time and the time between data points shall not be greater than one minute.
- S. Stand-alone Capability - Demonstrate stand-alone controller capability for each central mechanical system, each air handler, and each zone. Zones with identical controllers and identical sequences may be randomly tested one controller per zone. Controllers shall provide stable and reliable stand-alone operation using default values or other method for values normally read over the network. Verify that a system alarm is generated indicating the communications failure for each controller in a stand-alone state.

END OF SECTION 250000

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SECTION 250501 – COMMON WORK RESULTS FOR INTEGRATED AUTOMATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Integrated Automation equipment coordination and installation.
 - 2. Sleeves for raceways and cables.
 - 3. Sleeve seals.
 - 4. Grout.
 - 5. Common Integrated Automation installation requirements.
- B. Related Sections:
 - 1. 250000 – INTEGRATED AUTOMATION
 - 2. 250990 – SEQUENCE OF OPERATION

1.3 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

- A. Product Data: For sleeve seals.

1.5 COORDINATION

- A. Coordinate arrangement, mounting, and support of Integrated Automation equipment:
 - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 - 3. To allow right of way for piping and conduit installed at required slope.
 - 4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
- B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

- C. Coordinate location of access panels and doors for Integrated Automation items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping".

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel.
 - 1. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
 - b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE SEALS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide one of the following:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Metraflex Co.
 - d. Pipeline Seal and Insulator, Inc.
 - 2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 - 3. Pressure Plates: Carbon steel. Include two for each sealing element.
 - 4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR INTEGRATED AUTOMATION INSTALLATION

- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both Integrated Automation equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- E. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR INTEGRATED AUTOMATION PENETRATIONS

- A. Integrated Automation penetrations occur when raceways, pathways, cables, wireways, or cable trays penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- E. Cut sleeves to length for mounting flush with both surfaces of walls.
- F. Extend sleeves installed in floors 2 inches above finished floor level.
- G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.
- H. Seal space outside of sleeves with grout for penetrations of concrete and masonry
 - 1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

- I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants".
- J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."
- K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

- A. Install to seal exterior wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.4 FIRESTOPPING

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for Integrated Automation installations to restore original fire-resistance rating of assembly.

END OF SECTION 250501

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SECTION 250990 – SEQUENCE OF OPERATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes a summary of all Integrated Automation which is principally Direct Digital Control (DDC System) related work.
- B. Related Sections:
 - 1. 250000 – INTEGRATED AUTOMATION
 - 2. 250501 – COMMON WORK RESULTS FOR INTEGRATED AUTOMATION

1.3 SUMMARY OF WORK

- A. This contract shall include the furnishing of all labor and materials required for the installation of new temperature regulating systems to monitor, control, and regulate automatically and completely the new air conditioning, ventilating, hydronic and heating systems, as shown on the accompanying drawings and hereinafter specified. The temperature control equipment shall be installed by trained mechanics and technicians employed by the manufacturer and working in conjunction with the other contractors.
- B. The Integrated Automation Contractor shall extend all requisite power and control wiring in conduit to the devices, equipment, panels, workstation, servers, etc. that are provided under their contract.
- C. The Integrated Automation Contractor shall provide all interface equipment required for interconnectivity of their system to the equipment, panels, servers, workstation, meters, etc. that are part of the Owner's system.
- D. The Integrated Automation Contractor shall coordinate installation of all devices, meters, sensors, etc. with other contractors and their systems.

1.4 CONTROLS FOR NEW DUAL TEMPERATURE WATER SYSTEM

- A. A new dual temperature water system with two (2) variable speed pumps and supply and return piping to circulate varying quantities of chilled water or hot water from campus loop to multiple fan coil units throughout the building.
- B. The following immersion type temperature sensors shall be provided by the Temperature Controls Contractor complete with wells for installation by the Piping Contractor.

1. In the supply and return water piping to the building (Quantity: 2).
- C. The following differential pressure transmitter shall be provided by the Temperature controls Contractor and installed by the Piping Contractor.
1. In the building, where shown between dual temperature supply and return water mains, one Rosemont self contained variable capacitance water differential pressure transmitter with 4-20 ma DC output signal. Refer to plans for mounting detail.
- D. Operation of Controls
1. Generally, only one of the dual temperature water pumps No. 3 or No. 4 shall operate at all times (other pump is standby and will be started by DDC controller if lead pump fails). In order to maintain equal runtime on each dual temperature water pump, DDC controller shall determine order in which pumps shall operate by performing an automatic lead change on a monthly basis.
 2. All season operation: When either dual temperature water pump No. 3 or No. 4 is operating, DDC controller, receiving signal from differential pressure transmitter located in building supply and return mains piping, shall provide speed signal to pump speed controller. Speed controller shall in turn, vary pump speed in order to maintain constant differential pressure in dual temperature water mains.
 3. Summer operation: Chilled water will be available for cooling from the campus chilled water piping loop. DDC controller shall position four (4) 2-way dual temperature water valves to the chilled water position for normal chilled water flow to the building. In addition, DDC controller shall position the mixing/emergency shutoff valve located in the return water piping from the building to the fully open position. However, DDC controller receiving signal from temperature sensor located in the campus chilled water return water piping from the building shall override controls to completely shut the mixing/emergency shutoff valve if the temperature of the water in the chilled water return piping exceeds 120°F (DDC adjustable).
 4. Winter operation: Hot water will be available for heating from the campus hot water piping loop. When the season changes over from summer to winter mode, DDC controller shall position four (4) 2-way dual temperature water valves to the hot water position for normal hot water flow to the building. In addition, since the temperature of the hot water being supplied to the building is generally too hot for building use, DDC controller, receiving signal from temperature sensor located in the supply piping shall modulate the mixing/emergency shutoff valve to maintain present hot water temperature reset schedule based on outdoor air temperature.

1.5 CONTROLS FOR FAN COIL UNITS

A. Occupied

1. The supply fan will run at low speed.
2. On call for heat, the discharge air temperature will maintain set point.

B. Unoccupied

1. The supply fan will be off. On a call for heat when the outdoor temperature is below 32°F, the hot water valve will be open 10% per 1.8°F (100% at 14°F).

C. Heat – Modulated

1. The supply fan will run and the valve will modulate open or closed based on the demand from the heat PID loop.

D. Cool – Modulated

1. The supply fan will run and the chilled water valve will modulate open or closed based on the demand from the cool PID loop.

1.6 SYSTEM INPUT/OUTPUT SCHEDULES

- A. Refer to Input/Output Schedule.

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CONTROL SYSTEM POINTS - INPUT/OUTPUT SUMMARY											
FOR SCHMIDT HALL											
XAVIER UNIVERSITY											
DEVICE MARK	CONTROL POINTS	INPUTS/OUTPUTS				CONTROL	MONITOR	ALARM	DATA	DETAIL	COMMENTS
		AI	DI	DO	AO						
POINT NAME DESCRIPTION											
FAN COIL UNITS (2-12): 10 NEW UNITS										M2.0	
FAN	FAN ENABLE/DISABLE			X		X					
T-1	ROOM TEMPERATURE SENSOR	X									
TT-1	SUPPLY AIR TEMPERATURE TRANSMITTER	X				X					
TCV	DUAL WATER TEMPERATURE CONTROL VALVE				X	X					
FAN COIL UNIT (2-6): 1 NEW UNIT										M2.0	
FAN	FAN ENABLE/DISABLE			X		X					
T-1	ROOM TEMPERATURE SENSOR	X									
TT-1	SUPPLY AIR TEMPERATURE TRANSMITTER	X				X					
TCV	DUAL WATER TEMPERATURE CONTROL VALVE				X	X					
MAKEUP AIR UNIT 1: 1 NEW UNIT										M2.1	
EF-1	EXHAUST FAN ENABLE/DISABLE			X		X					(CONTROL POINT VIA TRANSFORMER SWITCH)
EF-1	EXHAUST FAN STATUS		X				X	X			(CONTROL POINT VIA TRANSFORMER SWITCH)

SECTION 260000 – ELECTRICAL WORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes a summary of all Electrical related work.

- B. Related Sections:

1. 260400 – General Electrical Requirements
2. 260500 – General Electrical Provisions
3. 260510 – Apparatus Coordination, Inspection, and Testing
4. 260519 – Wires and Cables
5. 260526 – Grounding and Bonding
6. 260529 – Supporting Devices
7. 260533 – Raceway and Boxes
8. 260534 – Junction and Pull Boxes
9. 260535 – Raceway Fittings
10. 260553 – Electric Identification
11. 262730 – Taps, Splices, and Terminations
12. 262816 – Enclosed Switches and Circuit Breakers

1.3 DESCRIPTION

- A. The General Conditions, Special Conditions and Division 1 through Division 32, as set forth in these specifications, are hereby incorporated into and shall become a part of the specifications for work under this title, insofar as they apply hereto.
- B. Furnish material, labor, tools, accessories and equipment to complete and leave ready for operation all Electrical systems for this project as described in these specifications and as shown on the drawings, or as required.

1.4 SCOPE OF WORK

- A. Work includes, but is not limited to:

1. Installation of feeders and branch wiring including overload and disconnecting means.
2. Wiring devices, multi-gang back boxes plates and supporting hardware and/or equipment.
3. Wiring of equipment and final connections of equipment furnished by others.
4. Required material and labor necessary to complete project scope as indicated within complete specifications, drawings or schedules

1.5 EQUIPMENT

- A. Any and all costs associated with piping, electric, wiring, conduit, supports, pads, or other modifications to accommodate installation for manufacturer's equipment that differs from equipment layout on drawings shall be included on contractor's bid. The contractor is responsible to insure that the equipment will fit within space allocated with appropriate clearances for maintenance, operation, servicing, and code.

1.6 QUALIFICATIONS

- A. Installer: Company specializing in performing the work of this Section with minimum three years documented experience.

1.7 LICENSES

- A. The installation of this Electrical work shall be made by Contractors and craftsmen licensed by the Governing Authorities.
- B. Obtain all permits, plan revisions, inspections, and licenses required by code authorities having jurisdiction.

1.8 FEES

- A. The Owner will obtain and pay for the building permit. The Contractor shall obtain all inspections or additional permits required by all laws, ordinances, rules, regulations or public authority having jurisdiction and obtain certificates of such inspections and permits and submit same to the Architect. The Contractor shall pay all fees, charges and other expenses in connection therein for Electric work including inspection fees, etc. associated with the building permit.

1.9 CODES, REGULATIONS AND STANDARDS

- A. Unless otherwise noted, the following latest enforced Edition shall apply to this work:
 - Ohio Building Code
 - National Fire Protection Association
 - National Electrical Code
 - Ohio Fire Code
 - OSHA Requirements
 - EPA Requirements

1.10 QUALITY ASSURANCE

- A. The Electrical Contractor shall be responsible for all costs caused by the change of equipment from the basis of design specified to other named manufacturers. The Contractor is responsible to insure that the other manufacturer named supplied equipment will fit within space allocated, with appropriate clearances for maintenance, operation, service, code requirements, etc. Any contractor utilizing a manufacturer other than basis of design shall be responsible for any additional requirements for electrical service, concrete pad size, physical space limitations, and capacities at no additional cost to the building Owner. If manufacturers are listed, no other manufactures except those listed within the Sections of this Division, that are able to

comply with the contract document requirements and minimum standards of these specifications, will be acceptable.

- B. Work provided or performed by the Contractor shall be guaranteed to be replaced and made good at his own expense any defects which may develop, within one (1) year after final payment and acceptance by the building Owner, due to faulty workmanship or material, upon receipt of written notification of the defect from the building Owner.

1.11 COORDINATION DRAWINGS

A. General:

1. The HVAC Contractor shall be in charge of the coordination drawing process and shall be responsible to resolve all conflicts and settle any disputes resulting from the coordination drawing process.
2. Contract drawings are diagrammatic. Included in the base bid shall be all offsets, fittings, etc. for a completed project.
3. Field discrepancies shall be resolved by the field foreman. When discrepancies cannot be resolved, the signed-off coordination drawings shall be re-examined for rights.
4. Documented, coordinated, dimensioned work will have precedence. Owner will not pay for rework of a particular trade. Uncoordinated work will not be tolerated.
5. Each Contractor shall coordinate the exact location of their work with the work of other trades prior to fabrication or installation of same. Verify all dimensions and elevations. Provide additional offsets and sections of material as may be required to meet the applicable job condition requirements. Coordinate with and review all related Construction Drawings and Shop Drawings of all equipment suppliers prior to start of work.
6. It is the responsibility of the Electric Contractor to coordinate between his equipment suppliers and his temperature control subcontractor and other subcontractors as to which control devices are supplied with equipment, required wiring and voltages, and other related coordination times, so as to ensure a complete, proper, and operable installation.

B. Process

1. The HVAC Contractor shall have precedence for the allotment of available space. Ductwork rerouting for gravity drain lines may be required and shall be approved by the Engineer.
2. The HVAC Contractor shall be responsible for all trades, pre-coordinating their layouts and shop drawings with each other, including the Electric Contractor.
3. The HVAC Contractor shall prepare drawings in ACAD Release 2014 or newer edition. All ACAD files shall be saved suitable for release 2014. He shall be responsible for the base drawings to be used by all other Contractors. Base drawings shall include architectural, structural and reflected ceiling plan information.
4. The HVAC Contractor shall prepare ductwork drawings, at a minimum scale of $1/4" = 1'-0"$, in ACAD Release 2014 or newer edition. Finished CD with base drawing and ductwork, it shall be circulated in the following order:
 - a. Plumbing Contractor

- b. Piping Contractor
 - c. Electrical Contractor
 - d. General Contractor
5. Each Contractor shall use the CD for preparation of their installation drawings.
 6. After all trades have completed the coordination process, the General Contractor shall hold a coordination meeting to resolve conflicts. Each Contractor shall have available a drawing of his layout to be used with a light table for overlaying purposes. A representative of each Contractor, the Architect and the Engineer shall attend. All conflicts shall be resolved at the coordination meeting. The Architect and Engineer shall resolve all major conflicts as to the degree each Contractor shall alter their layout in order to allow for sufficient space for installation of the work.
 7. After all work is coordinated and all conflicts resolved, each contractor shall update coordination documents in order to reflect all required minor and major modifications.
 8. When all coordination is complete, the HVAC Contractor shall distribute two (2) sets of prints of the revised coordination drawings to each of the trades involved in the project, one (1) set for the Owner's Representative and one (1) set for as-built drawings.
- C. HVAC Contractor:
1. All horizontal ducts shall be located and dimensioned from column center lines. Each duct shall be drawn to scale with width, depth and bottom of duct elevation clearly noted.
 2. All vertical ducts shall be located from column center lines in two (2) directions. When concealed in a shaft, each vertical duct shall be shown in its total length.
 3. Terminal units, heating coils, fire dampers, grilles and diffusers shall be located and dimensioned. Terminal units shall be located so as to be readily accessible from removable ceiling panel or access panel. All necessary clearances, required by codes, shall be maintained.
- D. Electrical Contractor:
1. Conduits less than 1" in size are not required to be indicated on coordination drawings; however, the Electrical Contractor is responsible for routing these conduits in a manner to not cause a conflict with other trades. Conduits not indicated on coordination drawings shall be field offset to avoid all conflicts.
- F. General Contractor:
1. All furrings and holes shall be clearly noted.
 2. All ceiling heights shall be clearly noted.
- G. Service Areas:
1. Contractors shall indicate service areas for all equipment, terminal units, etc. by shaded areas on drawings.

PART 2 - NOT APPLICABLE

PART 3 – EXECUTION

3.1 EXISTING WORK

- A. Each Contractor shall locate existing site utilities, installed in previous phase, prior to beginning work. Provide adequate means of protection during work operations. Repair existing utilities damaged during work operations to the satisfaction of the utility owner and at Contractor's expense.
- B. Should uncharted or incorrectly charted piping or other utilities be encountered during work operations, notify the Engineer immediately for procedure directions. Cooperate with utility companies in maintaining active services and facilities in operation.

3.2 OPENING LOCATIONS AND CUTTING

- A. Each Contractor shall give the General Contractor locations and sizes of all openings required for the installation of new mechanical work before new walls, etc. are started.
- B. All cutting through poured concrete slabs and walls shall be done with core drills. No jack hammers will be allowed. All cutting and patching by General Contractor that is coordinated by the Electric Contractor. All cutting and patching not coordinated by the Electric Contractor with the General Contractor shall be by the Electric Contractor.

3.3 CLEANING AND PAINTING

- A. All equipment shall be kept dry and clean during the construction period.
- B. Prime and paint by General Contractor, unless otherwise noted.
- C. When all work is completed and all work has been satisfactorily tested and accepted by the Architect, mechanical equipment and other exposed surfaces shall be thoroughly cleaned.
- D. Repair marred and damaged factory painted finish with materials and procedures to match original factory finish.

3.4 PROTECTION AND DAMAGE

- A. In addition to the provisions and stipulation of the General Conditions, each contractor and subcontractor shall provide various types of protection as follows:
 - 1. Protect finished floors from chips and cutting oil by the use of metal drip receiving pan and oil proof floor cover.
 - 2. Protect equipment and finished surfaces from welding and cutting splatters with baffles and splatter blankets.
 - 3. Protect equipment and finished surfaces from paint droppings, insulation adhesive and sizing droppings, etc. by use of drop cloths.
- B. All equipment shall be stored at the site with openings, bearings, etc., covered to exclude dust and moisture. All stock piled pipe shall be placed on dunnage and protected from weather and from entry of foreign material.

- C. Conduit and construction openings and excavations required for Electrical work shall be covered when work is not in progress as follows:
 - 1. Cap pipe openings with fittings or plugs.
 - 2. Cover wall and ceiling openings with plywood, or canvas covered framing.
 - 3. Cover floor openings and excavations with structural material of adequate strength to support traffic.

- D. The Owner's property and the property of other Contractors shall be scrupulously respected at all times (including damage from leaks). Provide drop cloths and visqueen or similar barriers where dust and debris is generated, to protect adjacent area.

- E. Contractor shall be held responsible for damage caused by his work or through neglect of his workmen. Repairing of damaged work shall be done by Contractor as directed by the Architect. Cost of repairs shall be paid by Contractor.

- F. The Owner reserves the right to make emergency repairs as required to keep equipment in operation without voiding the Contractor's guarantee bond not relieving the contractor of his responsibilities during the bonding period.

END OF SECTION 260000

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SECTION 260400 – GENERAL ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 GENERAL

- A. The following paragraphs are applicable to Division 26 and are complementary to other sections of specifications. Where items described in other sections of the specifications are repeated herein, it is done to call special attention to or to qualify them, but it is not intended that any part of the documents shall be assumed to be omitted if not repeated herein.
- B. Where contradictions occur between this section and Division 1, the most stringent of the two shall apply. Architect/Engineer shall decide which is most stringent.

1.2 DRAWINGS AND SPECIFICATIONS

- A. Electrical drawings are diagrammatic and indicate general arrangement of systems and work included in the contract and shall be adhered to insofar as possible. The drawings and specifications are complementary and are intended, without giving every minute detail, to cover a workable installation complete in every respect including, whether mentioned or not, all material and equipment usually furnished with such systems and/or needed to make a complete operational installation omitting only such parts as are specifically excepted.
- B. Consult drawings and details for exact location of fixtures and equipment, and where not definitely indicated, request this information in writing.
- C. The specification for this division of the work is written in sectional form for brevity and convenience in reference, without repeating in each section all applicable general clauses and/or pertinent data covered elsewhere in the specification, but it is not intended that any of the documents shall be assumed to be omitted if not repeated in this division.
- D. Where specifications are written for brevity, with incomplete sentences, the omission of words or phrases, such as "this contractor shall", "shall be", "provide", "furnish", "all", etc. are intentional and such omitted words or phrases shall be supplied by inference; unless otherwise mentioned, such clauses, lists, and/or directives indicate work to be done by this contractor for that specific branch of work.

1.3 EXISTING WORK AND/OR VERIFYING CONDITIONS

- A. The work under this contract occurs on the site of and within the existing facility. The Owner will continue to use the present building during the construction period. The work under this contract shall be scheduled and performed so as to provide a minimum of interference with the normal operation of the existing building.

- B. Before submitting a proposal, Electrical Contractors shall visit the site, and shall also carefully examine all bidding documents including those for other branches of the work, to satisfy themselves as to the nature and scope of all work to be done. Prints showing the original building architectural, structural, mechanical, and electrical work are available at the Engineer's office for contractors' review
- C. The submission of a proposal shall be taken as evidence that such an examination has been made and difficulties, if any, noted. Later claims for labor, work, material, and equipment required for any difficulties encountered which could have been foreseen, shall not be recognized, and all such difficulties shall be properly taken care of by this contractor at no additional expense to the Owner.
- D. The accompanying drawings and specifications illustrate and describe the existing conditions, mechanical and electrical utilities, sewers, water mains, pipes, ducts, conduits, etc. that are particularly relevant to the new work insofar as these mains are shown on existing records or evident by field inspections and tests; however, it is not the intent that these documents shall be construed to guarantee to the contractor the exact location of these items. The contractor shall verify and determine the exact location of these items in the field, and all work under this contract shall be executed to avoid conflict with or damage to existing work. The work shall be planned and executed to avoid interference, as much as possible, with the normal use of the existing building.
- E. All work involving hazards to persons shall be suitably barricaded and provided with warning lights or signs, as required.
- F. Where necessary for the performance of the contract, existing work shall be cut, altered, removed, or temporarily removed and replaced. Work that is altered or replaced shall match similar existing work and said work shall be performed by trade applicable to the work; if said work is NOT shown or noted the Drawings relating to applicable trade, cost shall be paid by contractor requiring said work. However, unless otherwise provided by the drawings or specifications, no structural members shall be cut or altered without authorization of the Architect and Engineer. Work remaining in place, which is damaged or defaced by reason of work done under this contract, shall be restored in kind equal to its condition at the time of award of the contract by applicable trade as hereinbefore specified.
- G. Existing work shall not be disturbed further than necessary for proper installation of new work. New work to be connected or made integral with existing work shall be properly erected to secure solidity and be continuous in finish. Such new work in extension of existing work shall correspond in all respects with that to which it connects, or similar existing sound work, unless otherwise specified.

1.4 ALTERATIONS TO EXISTING WORK

- A. Alterations and additions to existing work shall include the requisite dismantling of the old equipment, rigging, wrecking, hauling, protection of permanent equipment and the building structures, and cleaning up. Care shall be exercised to keep dust and dirt to a minimum and to confine it to the area where the removal work is being performed. All debris shall be promptly removed.

- B. If asbestos insulation is encountered on any existing wiring which is to be removed or remodeled, contractor shall immediately notify Owner of the existence of asbestos and Owner will arrange proper removal of same without cost to contractor.
- C. Unless otherwise noted, remove all other existing equipment and conduit, wires, boxes, etc. which will not be reused in the final arrangement. Unless otherwise noted, all items which will be removed by this contractor and not reused shall become the property of the contractor and shall be promptly removed from the site by him.

1.5 EXISTING MECHANICAL AND/OR ELECTRICAL FACILITIES

- A. Where existing mechanical and electrical facilities and/or service lines occur in the area of the work and such facilities or lines are to be abandoned or changed, the contractor for the branch of work or trade involved shall cut off and properly cap the old lines, so as not to interfere with the new construction work. If any portions of such lines are required for the operation of the existing building the lines shall be altered and relocated to clear new construction and shall also be restored into service to provide continued operation of the existing building.

1.6 INTERRUPTION OF SERVICES

- A. The existing facility will be occupied and will remain in operation throughout the period that this work is being performed, and certain new work will be performed during this period. Unscheduled interruptions of the facility will not be tolerated. The contractor shall exercise extreme caution, shall thoroughly inform his workmen and subcontractors of the critical nature of this work, and shall continually review the work procedure being followed in order to prevent accidental interruption of service. Before performing any act which could result in interruption of service, the contractor shall notify the Owner and Engineer of the hazards involved and the contractor shall proceed in a manner and at a time specifically approved by the Owner and Engineer.
- B. All work necessitating the temporary turning off or shutting down the operation of existing mechanical and/or electrical facilities shall be done at times specifically approved by the Owner in advance of any disruption of existing facilities.

1.7 MATERIALS AND EQUIPMENT

- A. All materials and equipment entering into the work shall be approved by the Architect and Engineer, and must be new, without defects, and of the sizes and capacities shown on the drawings or hereinafter specified. All manufactured materials or equipment shall bear the identification mark of the manufacturer or, if required by the Architect and Engineer, shall be certified by an approved testing laboratory. All equipment shall operate within the manufacturer's range of speeds, guaranteed capacities, performance, etc. as indicated by the manufacturer's latest catalog and/or engineering data, shall be of proper size and dimension for the allocated space, and shall be placed in the space allocated in the proper construction sequence. Special consideration will be given to equipment which has been in successful field use or similar applications for at least three (3) years (exclusive of field tests), and to equipment which has an extended guarantee period in lieu of long use period. This contractor shall submit with his bid complete data on equipment he proposes to use;

failure to so submit, or to meet these requirements fully and those of the specifications, shall be grounds for rejecting the items.

- B. All electrical materials, apparatus, and equipment shall be new, of the make and characteristics specified, shall conform to NEMA standards, and shall be designed to comply with and be installed in accordance with the latest rules and regulations of the National Electrical Code, and all of the legally constituted public authorities having local jurisdiction. Upon completion of the work, furnish a certificate of approved inspection from an approved electrical insurance inspector. Verify the exact voltage and current characteristics at the building before ordering motors or similar equipment.
- C. Conduct such tests and adjustment of equipment as specified or necessary to verify performance requirements. Submit data taken during such tests.

1.8 QUIET OPERATION

- A. The work shall be installed in such a manner that under all conditions of load it shall operate without sound or vibration which is objectionable in the occupied spaces, in the opinion of the Architect and Engineer.
- B. In case of moving machinery, sound or vibration noticeable outside of the room in which it is installed or annoyingly noticeable inside its own room will be considered objectionable. Sound or vibration considered objectionable shall be corrected by the contractor.

1.9 PROTECTION

- A. In performing this contract, safeguard workmen and the public and protect the work and equipment until final completion and acceptance. After delivery and before and after installation, protect work against theft, injury, or damage. Carefully store material and equipment received on site which are not immediately installed. Close open ends of work with temporary covers or plugs during construction to prevent entry of obstructing materials. Protect related or adjacent work and the material of the other trades or the Owner from damage that might be caused by this work and make good any damage thus caused. Provide all safeguards, scaffolding, drop cloths, etc. as required.
- B. No welding or soldering shall be done near combustible materials of any kind; all adjoining work, finished surfaces, glass, etc. shall be protected from flames, sparks, hot metal, etc. by metal guards or approved noncombustible drop cloths or barriers.
- C. Each contractor shall replace any items or portions thereof wherever removed or damaged, in a manner equal to the original construction and finish, or where directed by the Architect and Engineer, contractor shall pay other trades to perform this work.
- D. All mechanical and electrical equipment with a factory finish shall be protected during construction and must be free of dust, dirt, cement splatters, etc. when building is turned over to the Owner. Dents and marred finishes are to be repaired to the satisfaction of the Architect and Engineer, or a replacement furnished where necessary.

1.10 EXECUTION OF WORK

- A. Promptly upon award of contracts, the Electrical subcontractor shall confer with the General Contractor and Engineer and the other subcontractors to prepare a time schedule for completion of the work. The electrical work shall be performed and coordinated with the program of the General Contractor and the other subcontractors. Each subcontractor shall proceed diligently with the work and shall cooperate with the General Contractor and the other subcontractors to maintain the approved project construction and progress schedule to the best of his ability and as conditions permit.

1.11 GENERAL SUPERVISION AND INSTALLATION OF WORK

- A. Each contractor shall at all times give the work his best skill and attention, including adequate construction supervision over his work, employees, and sub-contractors, and he shall fully cooperate with and confer with the Architect and Engineer and other contractors so that the best possible installation shall be obtained. Exact locations and relations are to be determined in the field, subject to the approval of the Architect and Engineer, and with preference to the dimensioned drawings and approved shop and setting drawings.
- B. Unless otherwise shown, conduits, etc. shall be exposed.
- C. Install conduits, etc. in a neat and workmanlike manner, close to walls, generally as high as possible, true and square to the building, utilizing standard practices, and properly graded for correct functioning of the system involved; multiple lines in close proximity shall be coordinated and neatly grouped. Install work in proper construction sequence and arranged so as to be readily accessible for operation, maintenance, and repair; minor deviations from drawings may be made to accomplish this, but changes of magnitude or which involve extra cost shall not be made without approval. All fixtures, outlets, etc. shall truly center with the adjacent architectural finish. All work, both exposed and concealed, shall meet the approval of the Architect and Engineer regarding neatness of appearance, location, and practicability of installation. The Architect and Engineer reserve the right to direct the removal and replacement of any item which, in his opinion, does not present an orderly and reasonably neat and workmanlike appearance.
- D. Each contractor shall cooperate with the General Contractor in the preparation of the "Coordination Drawings". The contractor shall familiarize himself with the work of the other contractors, shall lay out his work to meet conditions at the building, shall give freedom to and prevent conflict with the work of other contractors, and shall make reasonable modification in locations or arrangement from those indicated on the drawings if required to avoid conflicts or to conform to tile, wood, marble, or other architectural finish. From time to time as the work progresses, each contractor shall examine the work installed by others, insofar as it may affect his work, and he shall, before proceeding with the work, notify the Architect and Engineer in writing, and shall not proceed until directed by the Architect and Engineer, if any condition exists which prevents the successful installation of his own work.
- E. If the contractor places any work in violation of any of the above mentioned requirements, and conflicting or unworkmanlike conditions result, he shall, without additional charge, remove and reinstall or satisfactorily readjust such portions of his

work as may be necessary and as the Architect and Engineer may direct. The Architect's and Engineer's decision regarding such conditions shall be final.

1.12 ENGINEER'S OBSERVATION

- A. Periodic observation of the work by the Engineer is only for the express purpose of verifying compliance by the contractor with the contract documents to the best of his knowledge. Such engineering observations and services rendered by the Engineer or his representatives shall not be construed as the supervising of construction; nor the assuming by the Engineer of the duties and responsibility of the contractors; nor making the Engineer responsible for providing a safe place or procedure for the performance of the work or for the contractors' employees or for sub-contractors.

1.13 SLEEVES, CUTTING, PATCHING, CLEANING, WATERPROOFING, ETC.

- A. Provide and accurately set frames and Schedule 40 steel pipe sleeves for required openings in new work to minimize cutting. Perform all cutting, patching, etc. required to install the work. Use approved power operated boring machine for small holes wherever practical. Remove all rubbish incidental to the work. Where any work pierces waterproofing, provide all necessary sleeves, caulking, and flashing required to make openings absolutely watertight.
- B. Refer to the ACI Code 381.71, Section 6.3 for limitations and requirements for penetrations and openings.

1.14 PATENTS

- A. The contractor shall defend and guarantee the Owner against any expense, claims, litigation, etc. occasioned by the use in this work of any materials, devices, etc. covered by patents not owned by this contractor, or of which he is not a licensed user.

1.15 CONTEMPLATED WORK

- A. The drawings and specifications for the mechanical and electrical portion of this project have been prepared by Motz Consulting Engineers, Inc., doing business as Motz Engineering.
- B. The various items of work necessary for completion of this work are hereinafter specified under the respective section headings or shown on accompanying drawings, and shall be included in any contract or contracts made for completion of respective divisions of the work. Such contracts shall also include necessary details reasonably incidental to the proper execution and completion of such work.

1.16 MOVING MATERIALS

- A. If it becomes necessary at any time during the progress of this work to move materials which have been temporarily located and which are to enter into the final construction, the contractor furnishing said materials shall, when so directed by the Engineer, move

them or cause them to be moved. Cost of such moving shall be included in the contract price.

1.17 ACCIDENT PREVENTION

- A. Precaution shall be exercised at all times for the protection of persons and property. The safety provisions of applicable law, building, and construction codes shall be observed. Machinery, equipment, and other hazards shall be guarded in accordance with safety provisions of the "Manual of Accident Prevention in Construction" published by Associated General Contractors of America to the extent that such provisions are not inconsistent with applicable law or regulations.

1.18 TOOLS AND MATERIALS

- A. Tools and materials shall be stored on the premises at locations designated by the Owner.

1.19 PROPERTY PROTECTION

- A. All hoisting shall be done with proper tag lines and buffers to prevent damage to the sides of the building. Where it is necessary to hoist materials to the roof, the parapets at top of the building and the roof where materials are landed from hoists shall be protected with heavy wood covers. Parapet protection shall be placed on both sides and top, and shall extend far enough on either side of landing point to insure adequate cover. The roof, from the landing point at parapet to final location of material, shall be adequately protected by planks laid side by side on roofing and spiked together on outside edges with planks running at right angles to main planking. The roof shall be adequately protected against leaks at all times.
- B. Where hoists are erected on the roof for hoisting material up the side of the building, the roof shall be adequately protected against abrasion or other damage. Materials stored on the roof shall be placed on planks or other protection approved by the Engineer and shall be placed only at locations approved by the Engineer.
- C. If hoisted materials are taken through windows, the jams, head, and sill shall be adequately protected with wood planking or proper buffers.
- D. Any work, equipment, or property damaged during construction of this project and due to operations under this contract shall be repaired or replaced by this contractor, without additional cost to the Owner. Upon completion of the work, the contractor shall remove all protections herein specified.

1.20 REMOVAL OF RUBBISH

- A. It shall be each contractor's duty to keep the building and surrounding premises clean, free from rubbish of every description. No rubbish, crating materials, packing, or dirt shall be allowed to accumulate at any time, but shall be removed at once and hauled away.

- B. Each trade shall be responsible for its own tools and materials during the periods of rubbish removal but contractors shall use reasonable care in removal of rubbish to protect the tools and materials of others against loss or damage. The Owner reserves the right, in the event that removal of rubbish is not promptly and properly carried out by the Contractors to have rubbish removed and to charge the cost of its removal to the contractor.
- C. Also, refer to Division 1.

1.21 MATERIAL SAFETY DATA SHEETS (MSDS)

- A. The contractor shall obtain and maintain on-site during the course of the project the Material Safety Data Sheets (MSDS's) for all chemicals or products containing chemicals that may be considered toxic or hazardous. The MSDS's are to be forwarded to the Office of Environmental Health and Safety upon completion of the project.

1.22 INSTRUCTION OF PERSONNEL

- A. The Electrical Subcontractor shall provide free on site instruction in the proper use of installed equipment to designated representatives of the Owner, sufficient to ensure safe, secure, efficient, non-failing utilization, and operation of systems. This instruction shall include the following:
 - 1. One Site Training: Provide a minimum of 24 hours of training for owner's staff. Submit a syllabus to the Engineer prior to the first session.
 - 2. Support: Provide a minimum of 16 hours of support either on site or by telephone to answer operations questions.

PART 2 – (NOT USED)

PART 3 – (NOT USED)

END OF SECTION 260400

SECTION 260500 – GENERAL ELECTRICAL PROVISIONS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Special Conditions, General Requirements, Division 1 Specifications, apply to this Section.

1.2 REFERENCE TO CONDITIONS OF THE CONTRACT

- A. The Conditions of the Contract General, Supplementary and other Conditions and Divisions 1 through 31 and General Requirements, apply to the work specified in Division “26” and “28”. Unless the specifications contain statements which are more definitive or more restrictive than those contained in the Conditions of the Contract, the specifications shall not be interpreted as waiving or overruling any requirements expressed in the Conditions of the Contract.
- B. No claim or additional compensation shall be entertained on behalf of or paid on account of failure to be informed of the above conditions and requirements.
- C. Should a bidder find discrepancies in or omissions from the drawings or specifications, or should he be in doubt as to their meaning, he should at once notify the Associate who shall send written instructions to bidders. If these are ignored by the Contractor, he shall be responsible for furnishing the proper or workable equipment as necessary.
- D. Before submitting a bid, bidders shall be held responsible to have visited the site of work, attend the Pre-Bid Meeting, and fully inform themselves as to existing conditions and limitations, including rules, rates and fringe benefits, travel pay, affiliation fees and transportation expense prevailing in the local labor market, and no allowance shall subsequently be made on behalf of the bidder by reason of any error on his part.
- E. Carefully examine the architectural, structural, heating, ventilating and air conditioning, plumbing and any other relevant contract documents. If any discrepancies occur within Contract documents, report such discrepancies to the Associate in writing and obtain written instructions as to the manner in which to proceed. No departures from the contract documents shall be made without prior written approval of the Associate.
- F. Obtain any additional reference documents and/or information required for installation prior to installing equipment. Coordinate work with other trades making minor adjustments as required. Wiring or conduit layouts are schematic based and exact locations shall be determined by structural or other restricting conditions.
- G. Minor details not usually shown or specified but necessary for proper installation and operation shall be provided in the Electrical Contractors estimate, the same as if herein specified or otherwise shown.
- H. Coordination with the Utility servicing this facility including following and policies of the utility company shall be included in this bid. Where material and installation is deemed the responsibility of the Electrical Contractor by the Utility Company, such work shall be included within his bid.
- I. Electrical Contractor bid submission shall give written notice to the Architect of record

any materials or apparatus believed inadequate, in violation of laws, ordinances, rules, standard installation practices and any necessary item required or work omitted. In the absence of such written notice, it is mutually agreed that the Electrical Contractor has included the cost associated of all required item in his proposal and that he will be responsible for the approved satisfactory functioning of the entire system without extra cost compensation.

1.3 WORK INCLUDED

- A. Provide and install a complete and operating electrical installation in accordance with these specifications and accompanying contract documents. This shall include required labor, material, apparatus and supervision.
- B. Without limiting or restricting the volume of work and solely for convenience, the work to be performed will, in general, comprise the following:
 - 1. Installation of feeders and branch wiring including overload and disconnecting means.
 - 2. Wiring of equipment and final connections of equipment furnished by others.
 - 3. Building grounding and bonding of equipment and electrical distribution system.
 - 4. Required material and labor necessary to complete project scope as indicated within complete specifications, drawings or schedules.
- C. Items of labor, material, and equipment not specified in detail or shown within Contract documents, but incidental to or necessary for the complete installation and proper operation of the several branches of work and described herein, or reasonably implied in connection herewith, shall be furnished as if called for in detail by the specifications or Contract documents. This includes electrical work associated with mechanical and plumbing work whether indicated on electrical drawings or not.
- D. This contractor is advised to carefully coordinate the delivery of large, awkward, heavy equipment, material or relevant items. Delivery limitations may require modifications, supporting means or structural modifications in order to set equipment or components. This contractor shall be responsible for all calculations, material, labor, equipment, machinery, deliveries, transportation or safety related equipment required for equipment such as but not limited to: transformers, switchgear, generator, site lighting, disconnects, staging materials, panelboards etc.
- E. Electrical Contractor shall provide raceways, fittings, supports, feeders, branch circuits, overload/short circuit protection, relays, starters, terminals and related accessories to complete his work including installation and termination of items, equipment or controls furnished by other contractors unless specifically stated otherwise.
- F. It is the responsibility of the Electrical Contractor to verify proper motor rotation and sizing of motor overload protection is in compliance with NEC and equipment manufacturer.

1.4 WORK NOT INCLUDED

- A. The following items of Electrical Construction are not included in this contract:
 - 1. Low voltage wiring of certain systems or devices shall be done by the respective Contractor such as temperature control wiring, interlock wiring and related control

devices for HVAC equipment unless noted or otherwise. Raceways shall be provided by the Electrical Contractor.

2. Certain motors and equipment shall be provided by others, complete with motor and built-in or separate controllers as covered by such contracts such as packaged HVAC or plumbing equipment. The Electrical contractor shall provide feeders, branch circuits and/or disconnecting means as called for within the Contract documents.

1.5 DEFINITIONS AND ABBREVIATIONS

A. Definitions

1. "Furnish" shall mean supply and deliver to project site, ready for unloading, unpacking, assembly, installation, etc., as applicable in each instance.
2. "Install" shall be used to describe operations at project site including unloading, packing, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protection, cleaning, and similar operations, as applicable in each instance.
3. "Installer" shall mean a company or individual specializing in performing work meeting the requirements of their trade with minimum of three (3) years of experience.
4. "Provide" shall mean furnish and install, complete and ready for intended use, as applicable in each instance.
5. "Directed" shall mean as directed by Forest Hills Local Schools or its Representative prior to installation of equipment.
6. "Indicated" shall mean "indicated on Contract Documents".
7. "Shown" shall mean "shown on Contract Documents".
8. "Section" shall mean one of the Specification Sections.
9. "Division" shall mean one of the Specification Divisions.
10. "Article" shall mean one of the numbered paragraphs of the Specification Section.
"Work" or "Electrical Work" herein includes products, labor, equipment, tools, appliances, transportation and related items, directly or indirectly required to complete the specified and/or indicated electrical installation.
11. "Code" shall mean any and all regulations and requirements of regulatory bodies, public or private, having jurisdiction over the work involved.
12. "Product" used in Division 26, 27 and 28 means material, equipment, machinery, and/or appliances directly or indirectly required to complete the specified and/or indicated Electrical Work.
13. "Standard Product" shall mean a manufactured product, illustrated and/or described in catalogs or brochures, which are in general distribution prior to the date of issue of construction documents for bidding. Products shall generally be identified by means of a specific catalog number and manufacturer's name.
14. "Wiring" shall mean fittings, conduits, wires, junction boxes, connections to equipment, splices, and other accessories required to complete the work.
15. Abbreviations and Symbols: See lists on drawings.
16. "This Contractor" shall mean the Contractor responsible for Divisions 26, 27 and 28 work.
17. Contract Documents: drawings, specifications, manufacturer's specification/data sheets, bid forms, addendum, and change orders.
18. Whenever the phrases "approved by the Associate or Owner's Representative,"

"approved equivalent," or "equivalent to" appear in these specifications, they shall be interpreted as meaning "as recommended by the Associate and approved by the Authority."

B. Reference to the latest editions of codes and standards shall mean:

<u>Reference</u>	<u>Definition</u>
NEC	National Electrical Code
ASTM	American Society for Testing Materials
NEMA	National Electrical Manufacturers Association
ANSI	American National Standards Institute
FS	Federal Specification, US Government
CS	Commercial Standards issued by US Department of Commerce
NESC	National Electrical Safety Code
NETA	National Electrical Testing Association
ADA	Americans with Disabilities Act
OBC	Ohio Building Code
NFPA	National Fire Protection Association
Owner	Owner / Owner's Representative

1.6 REGULATIONS

- A. Electrical work, equipment, and materials furnished and installed under this contract shall conform to the requirements of the latest edition of the National Electrical Code, the National Fire Protection Association and any other governmental or local authorities having jurisdiction. Pay any fees required for the installation of this Division work. Certificates of approval shall be obtained in duplicate from any department or agency issuing same, and shall be turned over to OWNER or its representative at the completion of the work.
- B. Provide any labor, materials, services, apparatus, CAD drawings and documents required to comply with applicable laws, ordinances, rules and regulations, whether or not shown.
- C. Obtain certificates of inspection and approval from authorities having jurisdiction and deliver same to OWNER as a prerequisite for final acceptance of the work. Provide record copies of permit applications, permits and other items for which certification are indicated.

1.7 SPECIAL ENGINEERING SERVICES

- A. In the instance of complex or specialized electrical systems such as fire alarm,

security, telecommunication or similar systems; the installation, final connections and testing of such systems shall be made under the direct supervision of qualified authorized service engineers who shall be in the employ of the respective equipment manufacturer. Provide OWNER with copies of instruction manuals and booklets for each system and piece of equipment installed. Provide any additional instructions over and above that listed above in the care, adjustment and operation of parts of the electrical systems.

- B. Pay any and all expenses incurred by these equipment manufacturers' representatives.

1.8 SUBMITTALS

- A. Shop drawings, product data, and samples shall be submitted to the Associate for approval. Submit a minimum of (6) sets (or equivalent documentation in PDF format) of shop drawings and related specifications to the Associate in a bound set included with letter of transmittal.
 - 1. Electrical Contractor must first review content for project specification compliance prior to submission. Drawings and specifications shall bear the Electrical Contractor's approval stamp indicating specification compliance. Sets received without Electrical Contractors approval stamp will not be reviewed.
 - 2. Shop drawings shall be new drawings, and not reproductions or tracings of the Contract Documents. In preparing shop drawings, establish lines and levels for the work specified, and check the drawings to avoid interference with structural features and other work. Immediately call to the attention of the Architect any interference for clarification in writing.
 - 3. Manufacturer's literature and data sheets shall be submitted indicating the necessary installation dimensions, weights, materials, and performance information. Each piece of literature shall be identified with the specific specification number, paragraph, and equipment schedule identification.
 - 4. Engineer's review of Manufacturer documents or specifications shall not relieve the contractor from responsibility of errors or omissions in such submittals, schedules, drawings or deviations form contract documents.
 - 5. Layout and detail drawings shall be submitted in the form of legible sepia reproducible and paper prints. Manufacturer's drawings shall be standard drawings. Equipment shop drawings shall show specific data and other special features required for review consideration.
 - 6. Equipment shop drawings (8-1/2 by 11 inch sheets) shall be bound together in sets, in loose leaf binders, and shall be indexed in accordance with Specification Section. Additional shop drawings may be submitted at a later date for insertion therein, and the original submittal shall note which shop drawings shall be submitted later. Marked-up catalogs are not acceptable, and shall be rejected.
 - 7. Materials and equipment shop drawings shall be submitted within 30 calendar days of Contract receipt.
 - 8. Manufacturers' instruction manuals shall be submitted together with shop drawings. Furnish instruction manuals and parts listed for each piece of electrical equipment, on 8-1/2 by 11 inch sheets, or catalogs, suitable for loose leaf side binding, packaged separately, and clearly identified. Instructions shall include information pertaining to installation, operation, and maintenance of equipment as applicable. Each piece of literature shall be clearly identified with the specific job equipment identification. Literature shall be factory printed and not reproduced copies.

9. Any characteristic of any piece of equipment which deviates from the characteristics of the equipment specified shall be hi-lighted and circled in red.

B. Submit manufacturers' data, and/or shop drawings of the following:

1. Emergency and safety related equipment.
2. Wiring devices.
3. Disconnect switches, motor starters, and controls supplied by the Electrical Contractor.

1.9 OPERATING AND MAINTENANCE INSTRUCTIONS

- A. After final tests and adjustments have been completed, furnish the services of qualified personnel to fully instruct the OWNER Maintenance representative in the operation and maintenance procedures for equipment installed. Operation and maintenance instructions for major items of equipment shall be directly supervised by the equipment manufacturer's representative. Supply qualified personnel to operate equipment for sufficient length of time as required to meet governing authorities' operation and performance tests and as required to assure that OWNER representatives are properly qualified to take over operation and maintenance procedures.

1. Notify the Associate, OWNER representatives and equipment manufacturers' representatives, by letter, as to the time and date of operating and maintenance instruction periods at least one week prior to conducting same.
2. Forward to the Associate the signatures of all present for the instruction periods.

- B. Furnish three (3) copies of recommended equipment operation and maintenance procedures manuals as specified herein, assembled and bound together in 8-1/2 by 11 inch three-ring binders. The ring binders shall be submitted to the Associate in accordance with procedures established for shop drawing submittals.

1. The operation and maintenance procedures manuals shall include the following:
 - a. Project Title
 - b. Associate's Name and Address
 - c. Date Submitted
 - d. Contractor's Name and Address
 - e. Index (in alphabetical order, with page numbers)
 - f. General Description of Each System
 - g. Parts List, identifying the various parts of equipment for repair and replacement purposes.
 - h. List of spares recommended for normal service requirements.
 - i. Operating instructions outlining step-by-step procedures required for system start-up and operation. The instructions shall include the manufacturer's name, model number, service manual, and brief description of each piece of equipment and its basic operating features.
 - j. Maintenance instructions describing routine maintenance and lubrication procedures and schedules, and simplified diagrams which illustrate the systems as installed.
 - k. Wiring and control diagrams for each piece of equipment, showing "as installed" conditions.

1.10 SINGULAR NUMBER

- A. References made to any item in the singular number shall apply equally to as many identical items that the work may require.

1.11 PROTECTION OF SERVICES

- A. Repair, replace and maintain in service any new or existing utilities, facilities or services (underground, overhead, interior or exterior) damaged, broken or otherwise rendered inoperative during the course of construction. The method used in repairing, replacing or maintaining the services shall be approved OWNER and Associate. OWNER reserves the right to make emergency repairs as required to keep equipment in operation without voiding the Contractor's guarantee bond not relieving the contractor of his responsibilities during bond period.
- B. OWNER's property and the property of other trades shall be scrupulously respected at all times include damage from leaks. This contractor shall provide drop cloths or similar barriers where dust or debris is generated protecting adjacent area.
- C. This contractor shall be held responsible for damages caused by his work or through neglect of his workman or subcontractors. Repairing of damages shall be done in accordance by OWNER or its representative. Costs associated with repairs shall be paid by this contractor.

1.12 PROTECTION OF FLOORS, EQUIPMENT AND PERSONNEL

- A. Protect flooring from damage during the construction period. Provide plywood or similar material under equipment or materials stored on floors, and in areas where construction may damage the floor surfaces. Replace floor surfaces (including sealer) damaged during the construction.
- B. In addition to the provisions and stipulation of the General Conditions, each contractor and subcontractor of shall provide various types of protection as follows:
 - 1. Protect finish floors from chips and cutting oil by the use of metal drip receiving pan and oil proof floor coverings.
 - 2. Protect equipment and finish surfaces from welding and cutting splatters with baffles and splatter blankets.
 - 3. Protect equipment and finished surfaces from paint droppings, insulation adhesives, grout, fire proofing and other related non-finished material.
- C. All equipment shall be stored at the site with openings, bearings, etc., covered to exclude dust, moisture or foreign debris from entering.
- D. Construction openings, trip hazards and unsafe conditions created by this contractor shall be scrupulously inspected for personnel safety and protection of property with strict compliance of OSHA work and construction practices.
- E. Conduit and excavations required for electric work shall be covered when work is not in progress such as capping conduit openings, cover wall or floor openings with material of adequate strength supporting construction traffic, safety warning tape, warning lights and signs.

1.13 SUBSTITUTIONS

- A. It is the intent of these specifications that wherever a manufacturer or product is specified, and the term "or approved equivalent" is used, the substituted item must conform in respects to the specified item. Consideration shall not be given to claims that the substituted item meets the performance requirements with lesser construction. Performance indicated in schedules, drawings and specifications shall be interpreted as minimum performance.
- B. Note that where specific manufacturers' products are indicated in the Contract Documents, the associated systems have been designed on the basis of that product's physical characteristics. Where specific manufacturers' products are indicated in the Contract Documents and other manufacturers' names are listed, the associated systems have been designed on the basis of the first-named manufacturer's product. When products other than those used as the basis of design are provided, additional costs related installation, usage or modifications to the systems and/or structure required by the use of that product shall be paid by this contractor.
- C. This Contractor shall be responsible for all costs associated with changes to sizes such as conduit, fuse, starter, wire, supports etc. caused by change of equipment from the basis of design including usage of other named manufactures. Space allocation due to usage of other manufacture shall be the responsible of the Contractor ensuring adequate clearances for maintenance, operation, service, code requirements are met.
- D. Equipment of one type shall be the products of one manufacturer; similar items of the same classification shall be identical, including equipment, assemblies, parts and components.
- E. Materials furnished shall be new, defect free, used in accordance to its listing and determined safe by a nationally recognized testing organization, such as Underwriters' Laboratories, Inc., or Factory Mutual Engineering Corporation, and materials shall be labeled, certified or listed by such organizations.
- F. Where a specific manufacturer is specified and other manufacturers' names are listed as equivalent, the bid shall be based upon the specified or equivalent manufacturers only. Any substitutions shall be submitted to the associate no later than ten (10) days prior to the bid opening. Refer to Article I and the General Conditions of this specification for more information.
- G. Final acceptance of substitutions shall be at the discretion of the associate.

1.14 PERFORMANCE OF EQUIPMENT

- A. Materials, equipment and appurtenances of any kind, shown on the drawings, hereinafter specified or required for the completion of the work in accordance with the intent of these specifications, shall be completely satisfactory and acceptable in operation, performance and capacity. No approval either written or verbal of any drawings, descriptive data or samples or such material, equipment and/or appurtenance shall relieve the Contractor of his responsibility to turn over the same to OWNER in perfect working order at the completion of the work.
- B. Any material, equipment or appurtenances, the operation, capacity or performance of which does not comply with the drawings and/or specification requirements or which is

damaged prior to acceptance by OWNER shall be held to be defective material and shall be removed and replaced with proper and acceptable materials, equipment and/or appurtenances or put in proper and acceptable working order, satisfactory to the school district, without additional cost to the Owner.

1.15 WEATHERPROOFING LOCATIONS (WP)

- A. Electrical apparatus, such as outlet boxes, switches, thermal switches, manual starters, disconnect switches, combination switches and starters, motor control centers, and motor starters shall be weatherproof gasket type, NEMA Types 4 in the following instances:
 - 1. On surface of exterior face of building, including areas where not under canopies, cast boxes with threaded hubs must be used and under canopies steel boxes with gasket connections to devices.
 - 2. In any areas where specifically noted "WP" or required by the NEC or Electrical Regulations mentioned herein.
 - 3. Within air conditioning enclosures.
 - 4. In underground splice boxes.
 - 5. On building roof.

1.16 CLEANING, PROTECTING AND ADJUSTING

- A. Materials shall be stored in a manner that shall maintain an orderly, clean appearance. If stored on-site in open or unprotected areas, equipment and material shall be kept off the ground by means of pallets or racks, and covered with tarpaulins.
- B. Equipment and material, if left unprotected and damaged, shall be repainted or otherwise refurbished at the discretion of the Owner. Equipment and material is subject to rejection and replacement if, in the opinion of the Associate or the manufacturer's engineering department, the equipment has deteriorated or been damaged to the extent that its immediate use or performance is questionable, or that its normal life expectancy has been curtailed.
- C. During the construction period, protect ductwork, raceways, conduit and equipment from damage and dirt. Properly cap ductwork and conduit.
- D. Vacuum cabinets, switch boards, distribution panels, lighting and power panels, etc., after completion of work.
- E. Remove recorded construction measurements from equipment, panels, walls or other defaced surfaces.

1.17 ACCESSIBILITY

- A. Coordinate to ensure the adequacy of the size of shafts and chases, and the adequacy of clearances in hung ceilings and other areas required for the proper installation of this work.
- B. Locate equipment which must be serviced, operated or maintained in fully accessible positions. Equipment requiring access shall include, but is not necessarily limited to, motors, junction boxes, fire alarm devices, controllers and switchgear.

- C. Provide, as required, the exact locations of access doors. Provide access doors in finished construction for installation by others. Locations of access doors in finished construction shall be submitted in sufficient time to be installed in the normal course of the work. Keep conduit and other electrical devices clear of access door openings to allow adequate space to work in or enter the concealed space.
- D. Access panels shall not be smaller than 12 inches by 16 inches or as required by authority of jurisdiction and shall be all-steel construction with a No. 16 gauge wall or ceiling frame and a No. 14 gauge panel door with not less than 1/8 inch fireproofing secured to the inside of the door. Doors shall be provided with concealed hinges and be secured with suitable clips and countersunk screws. Outside of access panels shall finish flush with finished wall or ceiling surfaces. Covers shall be factory primed with two (2) coats of primer.
- E. Working clearances: Provide at least 3'-0" of clear space in front of all electrical panels and as wide as the equipment with a minimum of 2'-6" wide. Height and width of working spaces shall be in accordance to Article 110.26 of National Electric Code.

1.18 GUARANTEE

- A. Guarantee material, equipment and workmanship for a period of one (1) year from date of final acceptance by Associate and Owner's Representative. Replace defective material and workmanship furnished and installed and other work and equipment damaged thereby.
- B. In addition to the one (1) year guarantee, furnish any warranties or guarantees that normally come with specific pieces of equipment that exceed the one (1) year guarantee. These additional warranties shall be given to OWNER for the time period specified.

1.19 COORDINATION

- A. The General Contractor shall be in charge of the coordination drawing process and shall be responsible to resolve all conflicts and settle any disputes resulting from the coordination drawing process. Coordinate and furnish in writing to other Primes, including the Associate, any information necessary to permit the work of all contractors to satisfactorily complete installation of their work with the least possible interference or delay.
- B. Each Prime Contractor shall participate in the preparation of coordination drawings. No installation of permanent systems shall proceed until the coordination drawings are approved by the General Contractor. No extra charges shall be allowed for changes required to accommodate installation of system by other contractors.
- C. Coordination drawings shall be prepared in Revit 2014 format for each floor level and shall be of a scale not less than 1/4 inch - 1 foot. Coordination drawings shall include equipment, lighting, telecommunication, fire alarm, cable tray and raceway plans, with elevations with dimensions. Coordination drawings shall also include required access points through ceiling panels, access doors, cover plates, etc.
- D. Field discrepancies shall be resolved by the field foreman. When discrepancies cannot be resolved, the signed-off coordination drawings shall be re-examined for rights. Any and all discrepancies in construction, phasing, etc., due to the lack of coordination shall

be at the sole expense of the associated contractors and in no way will be passed on to OWNER.

- E. Devices and appurtenances which are to be installed in finished areas shall be coordinated with the General Contractor and OWNER for final approval as it relates to location, finish, materials, color, and texture.
- F. When work is installed without proper coordination, changes to this work deemed necessary by the Associate shall be made to correct conditions without any extra cost to OWNER.
- G. Disciplines shall include in coordination: Electric, Telecommunications, HVAC, Mechanical, Plumbing, Fire Protection and Fire Alarm System.
- H. Related coordination specification in Division 01.

1.20 PRE-BID SITE VISIT

- A. Before submitting a bid, the Bidder is required to visit the site and fully inform themselves concerning all conditions affecting the scope of the work. Any discrepancies between the contract documents and the job site shall be brought to the Contract Officer's attention before bids are due. Failure to visit the site shall not relieve the Contractor from any responsibility in the performance of this Contract. No extra charges shall be allowed as a result of existing conditions.

1.21 DRAWINGS

- A. The Electrical drawings are diagrammatic and indicate the general arrangement of fixtures, equipment, furniture and work included in this contract. Consult the project documents and details for locations and dimensions of such equipment. All dimensions shall be field verified prior to material ordering. Where such items are not dimensioned or properly detailed, contact the Architect for required information.
- B. The Electrical Contractor shall follow the drawings in laying out work while checking drawings of other trades prior to installation. Maintain NEC required work clearances including overhead electric space requirements. Contact the Architect where clearances are inadequate prior to equipment installation.
- C. Where directed by the Architect, the Electrical Contractor shall modify layouts as needed to prevent conflict of work with other trades. No additional charges shall be made for coordination. Failure to coordinate with other trades or within project documents shall not relieve the Electrical Contractor from his responsibility or necessity of furnishing material or performing his work as required by the contract documents.

PART 2 - PRODUCTS

2.1 MATERIALS AND WORKMANSHIP

- A. Equipment shall be so built and installed as to deliver its full rated capacity at the efficiency for which it was designed. Equipment shall meet the detailed requirements indicated, and shall be suitable for the installation shown.
- B. Surface mounted electrical equipment shall be installed on 3/4" thick, fire retardant mounting board. Mounting board shall bear UL classified mark indicating ASTM E 84

test compliancy. Backboard material shall have a final applied finish according to manufacturer specifications prior to mounting of electrical equipment. Finishing material may include but not limited to fire retardant coatings. Backboard material shall minimally extend 6" in all directions beyond grouping of electrical equipment. The Electrical Contractor may use discretionary expertise to provide fire retardant backboard for individual equipment such as standalone disconnect switches, starters and the like. Where said devices are grouped (starters, disconnects, contactors etc.) installation shall include fire retardant backboard. Fire retardant mounting board installed on perimeter outside walls to be shimmed 1/2" from wall with washers to permit back ventilation.

1. Approved manufacturer: Hoover Treated Wood Products Inc. - Pyro-Guard
2. Approved equal.

- C. Where two or more units of the same class of equipment are furnished in same Section of Specifications, provide each from the same manufacturer. Furnish equipment and materials new and free from defects of size, make, type and quality herein specified, or as reviewed.
- D. Work shall be installed in a neat and workmanlike manner. Raceway installations shall parallel exterior and interior walls and be level. Vertical runs shall be plumb.
- E. Capacities, dimensions, or sizes specified or indicated are minimums, unless otherwise stated. Tolerances used in rating or testing standards specified shall not be allowed in determining capacities of equipment.
- F. Materials shall be listed by the Underwriters' Laboratories, Inc. where applicable and shall be manufactured in accordance with applicable standards established by ANSI, NEMA, ASTM, and IEEE.
- G. Any products judged not in accordance with the Specifications either before or after installation will be rejected. Costs associated with rejection shall be paid by this contractor.
- H. Where products are specified with no reference to a particular manufacturer's product, the product used shall meet or exceed industry construction and testing procedure standards applicable to the product, for life expectancy, performance and safety.
- I. Where electrical products are a fabricated assembly, the fabricator shall assume responsibility for correct operation of the entire assembly and of its individual components.
- J. Tools: Provide special tools for proper operation and maintenance of the equipment.
- K. It's the responsibility of the Electrical Contractor to provide clean electrical equipment which is free from dirt, paint, blemishes or markings. Scratches to equipment or enclosures shall be touched up with factory-color paint matching field color. Acceptance to restoration shall be to the satisfaction of the Architect.
- L. Required device or equipment adjustments shall be made by EC before and after equipment is in operation throughout the warranty period.
- M. Job site cleanliness and site safety of the removal of electrical generated trash or

debris is the responsibility of this contractor. All job site safety rules, regulations and requirements shall be followed and maintained.

2.2 IDENTIFICATION

- A. Switchgear, panels, relays, terminal control cabinets, junction boxes, contactors, circuit breakers, safety switches, motor starters, and similar items shall be identified with a single nameplate. Nameplates shall be laminated phenolic with white surface and black core (red surface for emergency and white core). Use 1/16" thick material for plates up to 2" x 4" and 1/8" thick for larger sizes. The lettering shall be condensed gothic with space between the lines equal to the width of the letters.
- B. Nameplate shall read as follows:
 - 1. First line shall be 1/2 inch letters stating panel/equipment name.
 - 2. Second line (if applicable) shall be 1/4 inch letters stating the existing panel name in parentheses ().
 - 3. Third line shall be 1/4 inch letters stating voltage/phase.
 - 4. Fourth line shall be 1/4 inch letters stating breaker number, panel number, and final room name/room number from which it is fed.
 - 5. Fifth line shall be 1/4 inch letters stating function and/or equipment which it controls.
- C. Names and numbers shall coincide with those listed within Contract documents unless altered by Owner descriptors.
- D. Nameplates shall be secured with screws, a minimum of one on each end.
- E. Label receptacle plates with identification showing panel and breaker number from which it is fed. Labels shall be made using the Dymo RinoPro or approved equal.
- F. Label junction boxes and pull boxes, showing circuit numbers contained in the enclosure. Use an approved marking device as noted.
- G. Label wire with an identification tag showing panel and breaker number from which it is fed at splices, junctions, and terminations as explained in this specification.
- H. Label fire alarm device bases with identification showing device address number assigned by fire alarm system manufacturer. Labels shall be made using the Dymo RinoPro or equivalent system.
- I. Branch breakers shall be labeled by Owner provided room numbers and descriptors.

2.3 ANCHOR BOLTS

- A. Provide and set in place, at the time of pouring of concrete foundations, necessary anchor bolts as required for the equipment called for under these specifications. Anchor bolts shall be of the hook type, of proper size and length to suit the equipment. Anchor bolts shall be set in pipe sleeves of approximately twice the bolt diameter and one half the embedded length of the bolt. Assume full responsibility for proper emplacement of the bolts.

2.4 INSERTS

- A. Provide inserts of an approved metallic type for hangers. Where two or more parallel

conduits are installed, continuous inserts may be used. Where required to distribute the load on the inserts, a piece of reinforcing steel of sufficient length shall be passed through the insert.

2.5 SLEEVES

- A. Provide sleeves in all roofs, floors, and any fire-rated walls. Each sleeve shall extend through its respective floor, wall or partition and shall be cut flush with each surface unless otherwise required.
- B. Sleeves in bearing and masonry walls, floors and partitions shall be standard weight steel pipe finished with smooth edges. For other than masonry partitions, through suspended ceilings, and for concealed vertical piping, sleeves shall be No. 22 USG galvanized iron.
- C. Sleeves shall be properly installed and securely cemented in place.
- D. Floor sleeves shall extend 1 inch above the finished floor, unless otherwise noted. Space between floor sleeves and passing conduit shall be caulked with graphite packing and waterproof caulking compound.
- E. Where conduits pass through waterproofed floor or walls, design of sleeves shall be such that waterproofing can be flashed into and around the sleeves.
- F. Where conduits pass through roofs, sleeves shall be installed and flashed and made watertight by the General Contractor unless otherwise specified or shown within Contract documents.
- G. Sleeves through exterior walls below grade shall have the space between conduit and sleeve caulked watertight using an approved method.

2.6 FIREPROOFING

- A. Where sleeves, ducts, cable trays, or other penetrations pierce floors or walls having specific fire ratings, the space between the sleeves and passing conduit shall be fireproofed with an approved UL listed fire proofing assembly. Installation method shall be per manufacturer's recommendations and approved by the Associate.
- B. Reference Division 7, section "Through-Penetration Firestop System".

2.7 WIRE GAUGE

- A. The sizes of conductors and thickness of metals called for herein or within other Contract documents shall be understood to be American Wire Gauge.

2.8 MISCELLANEOUS METAL AND STRUCTURAL STEEL

- A. Scope of Work: Furnish labor, materials, equipment and services necessary for the installation of miscellaneous metal and structural steel work required to complete this contract. Erect structural steel required for the proper support of equipment required under this contract.
- B. Supports, brackets, and clamps and other items specified herein shall be installed in strict accordance with the best practices and recognized code.

- C. Materials: Structural steel members required under this part shall conform to ASTM Standard Specification A-7. Other materials shall be as specified hereinafter.
- D. Priming: steel and iron work shall be primed with Rust-Oleum 769 or approved equivalent. Before priming, metal shall be thoroughly cleaned free from scale, rust and dirt.
- E. Anchors: Provide anchors, bolts, screws, dowels and connecting members, and do cutting and fitting necessary to secure the work to adjoining construction. Build in connecting members to masonry, concrete and structural steel as the work progresses.
- F. Supports and Brackets: shall be neatly constructed to structural shapes to adequately support the equipment intended. Supports must be approved prior to installation. Attention is directed to the proper rigid support required for conduit. Field conditions shall regulate the type of support required.
- G. Reference Division 7, Section "Spray fire-resistive Material" for coordination of hangers and applicable supports.

2.9 VIBRATION ISOLATION MOUNTS

- A. Provide vibration isolation mounts for all substations, power centers, transformers or equipment subject vibrations in accordance with this or other applicable sections.

2.10 MOTORS

- A. Motors shall be built in accordance with the latest standards of NEMA and as specified. Motors shall be tested in accordance with ASA C50 and conform thereto with respect to insulation resistance and dielectric strength.
- B. Each motor shall be provided with conduit terminal box and adequate starting and protective equipment as specified or required. The capacity shall be sufficient to operate associated driven devices under conditions of operation and load and without overload, and shall be at least the horsepower indicated or specified. Each motor type shall be premium energy efficient and of quiet operation.
- C. Motor starting equipment must be selected so that starting currents or transients do not have an adverse effect on lighting or other electrical equipment. This contractor shall provide devices or equipment required to snub or eliminate such electrical disturbances.
- D. Motors shall be verified for proper rotation prior to service of equipment.
- E. Motors connected to inverter controllers shall comply with the requirements of Division 23 Specification 230513 "Common Motor Requirements For HVAC Equipment" when included in Contract Documents.
- F. Motors shall comply with Energy Independence and Security Act of 2007.
 - 1. Motors shall comply with NEMA MG 1 table 12-11 and 12-12 unless noted otherwise.
- G. Motors connected to inverter controllers shall be inverter rated containing shaft mounted grounding protection ring such as AEGIS bearing protection ring.

PART 3 - EXECUTION

3.1 GENERAL

- A. Provide information to the General Contractor for any chases or openings required under this Contract. No cutting shall be done which may affect the building structurally or architecturally without the prior approval of the Associate. Damaged construction shall be restored to its original conditions and finished to match the surrounding work. Refer to "Supplementary General Conditions" for the disposition of Cutting and Patching.
- B. Grades, elevations, and dimensions shown on the drawings are approximately correct; however, field check and otherwise verify such data at the site before proceeding with work.
- C. The Contractor shall be entirely responsible for apparatus, equipment, and appurtenances furnished by him or his subcontractors in connection with the work and special care shall be taken to protect parts thereof in such manner as may be necessary or as may be directed. Protection shall include covers, crating, sheds or other means to prevent dirt, grit, plaster or other foreign substances from entering the working parts of machinery or equipment. Special care shall be taken to keep open ends of pipes closed while in storage and during installation. Where equipment must be stored outside the building, it shall be totally covered and secured with heavy weatherproofing tarps and kept dry at all times. Where equipment has been subjected to moisture, it shall be removed from the site and replaced with new equipment. Protect open excavating until covered over.
- D. Due to the schematic nature and small scale of the electrical drawings, it is not possible to indicate exact locations, offsets, fittings, access panels, pull boxes, and miscellaneous parts which may be required to form a complete system. The drawings are generally indicative of the work to be installed. Arrange work accordingly furnishing necessary parts and equipment as may be required to meet the various conditions and to provide a complete circuit from end use device to circuit protective device in panel.
- E. Within thirty (30) days after acceptance of bids, submit to the Associate for approval, a complete list of equipment and materials to be furnished under this contract, giving names and addresses of manufacturers and material cut sheets they intend to furnish.

3.2 CLEARANCES

- A. Take caution when routing conduit and location of equipment. In many cases, ceiling (plenums) clearance is limited due to ductwork and other mechanical lines, systems and structural steel. The Contractor shall be responsible for routing around mechanical equipment and ducts in order that everything can remain concealed in finished areas.

3.3 CUTTING AND PATCHING

- A. Provide cutting and patching necessary to install the work specified herein. Patching shall match adjacent surfaces. Refer to Section 01731, Cutting and Patching, for specific direction.
- B. No structural members shall be cut without prior approval of the Associate, and such cutting shall be done in a manner directed by the Associate.

- C. Provide ceiling removal and replacement where work above finished ceilings is required. Replace ceiling components damaged in the process.
- D. Provide patching where electrical devices are removed from or through walls, ceilings or floors.

3.4 PAINTING

- A. Finished painting shall be performed by this Contractor except for standard factory finishes.
- B. Electrical motor's, pump casings, and other similar items shall be provided with three coats of machinery enamel at the factory, and shall be carefully cleaned, rubbed down, and oiled after installation.

3.5 LOCATIONS

- A. Apply for detailed and specific information regarding the location of equipment as the final location may differ from that indicated on the drawings. Outlets, equipment or wiring improperly placed because of failure to obtain this information shall be relocated and re-installed without additional cost to the Owner. Determine the actual direction of door swings, so that local switches and other controls shall be installed at the lockside of doors, unless otherwise noted. Improperly located switches shall be relocated without additional cost to the Owner.
- B. The design shall be subject to such revisions as may be necessary to overcome building obstructions. No changes shall be made in location of outlets or equipment without written consent of the associate.
- C. Unless otherwise mentioned or indicated, mounting heights of outlets are shown on the drawings or in the specification. Dimensions given shall be considered to be from center of outlet to finished floor.
- D. Coordinate the exact location and elevation of all electrical devices and fixtures with the architectural interior elevation plan and reflective ceiling plan prior to installation.
- E. Properly rough in for the electrical conduit and equipment under this contract and modify as required for coordination during the construction period.

3.6 RECORD DRAWINGS

- A. During the construction period, maintain in good order a complete set of as-built electrical contract drawings. Record the actual electrical installation as the work progresses. Include changes to the contract and to equipment sizes and types. Keep these drawings available at the site at all times for inspection.
- B. Take proper caution against the use of superseded drawings. Check such copies and mark "void." Where drawings have been corrected by memorandum, assume the responsibility for marking all drawings so affected with the changes; such marked drawings shall remain in use until revised drawings are issued.
- C. At the conclusion of the work, provide to the Associate a complete set of drawings which indicate precisely how the electrical system, single line, and riser diagram equipment has been installed. Return such reproducible drawings within 30 days to the

Associate.

3.7 EQUIPMENT, FOUNDATIONS, SUPPORTS, PIERS AND ATTACHMENTS

- A. Provide necessary foundations, supports, pads, bases and piers required for equipment specified in this division; submit drawings in accordance with Shop Drawing Submittal requirements prior to the purchase, fabrication or construction of same.
- B. Provide concrete pads for base-mounted transformers and Electric Contractor provided rotating equipment and for other floor mounted electrical equipment. Pads shall be extended 6 inches beyond matching base in all directions with top edge chamfered. Inset 6 inch steel dowel rods into floors to anchor pads.
- C. Construction of foundations, supports, pads, bases and piers, where mounted on the floor, shall be of the same materials and same quality of finish as the adjacent and surrounding floor material.
- D. Equipment shall be securely attached to the building structure in an approved manner. Attachments shall be of a strong and durable nature and any attachments that are, in the opinion of the Associate, not strong and durable shall be replaced as directed. Reference Division 3 "Concrete".

3.8 SCAFFOLDING

- A. Furnish and erect scaffolding and ladders required in the installation of wiring, raceways, cable tray, equipment and lighting fixtures.

3.9 ENVIRONMENTAL AIR PLENUMS

- A. In spaces over suspended ceilings which are used for environmental air handling purposes as defined by Article 300.22C of the National Electric Code, power, data and communications cables must be in conduit or of the type cable rated for air plenum use. This Contractor shall be responsible to clearly define ceiling space used for environmental air purposes, provide material and installations meeting installation environment.

3.10 HAZARDOUS LOCATIONS

- A. In hazardous locations as defined by Article 500 of the National Electrical Code, electrical work installed in these areas shall be installed in accordance with the requirements of Article 500 whether specifically called for or not. Fixtures, fittings, and devices shall be installed according to, be rated for area of installation and meet requirements of binding code, including devices, seal offs, etc. Determine such areas as defined by the NEC and NFPA and conform to requirements of the enforcing agencies.

END OF SECTION 260500

SECTION 260510 – APPARATUS COORDINATION, INSPECTION & TESTING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Special Conditions, General Requirements, Division 1 Specifications, apply to this Section.

1.2 DESCRIPTION

- A. The intent of the inspection, testing and check-out work specified herein, or required, is to ensure that electrical workmanship and equipment is installed and performs in accordance with the design specifications, drawings, manufacturer's instructions and applicable codes and requirements. Also, it is intended to provide, ensure, or determine the following.
 - 1. If the equipment or installation has been subjected to damage during shipment or installation.
 - 2. If the equipment is in accordance with the purchase orders and Contract Documents.
 - 3. Provide initial acceptance tests and recorded data that can be used as a bench mark for future routine maintenance and trouble shooting.
 - 4. Ensure a successful start-up with a minimum of last minute interruptions and problems.
 - 5. Determine the suitability of the equipment and systems for energization and placing into operating service.
 - 6. Provide assurance that each system component is not only installed satisfactorily but performs and shall continue to perform its function in the system with reasonable reliability throughout the life of the system.
- B. Provide necessary supervision, labor, materials, tools, test instruments or other equipment or services and expenses required to inspect, test, adjust, set, calibrate, functionally and operationally check work and components of the various electrical systems and circuitry throughout the installation. Include the furnishing of sufficient personnel to assist operating forces in any additional checks that may be required for acceptance, start-up, run-in and placing the equipment and systems into continuous service.
- C. As specified herein, electrical equipment and systems shall be tested and adjusted in accordance with current NETA testing specifications. It will be acceptable for the testing of low-voltage systems such as fire alarm systems, security and access control systems to be performed by the equipment manufacturer.
- D. Contractor provided inspections and tests of the facilities, in accordance with recognized standards, in no way relieves the Contractor of the responsibility for the performance of varied tests, check-outs, and inspections required during the various stages of construction. Nor does it relieve or shift responsibility for the guarantee outlined in this specification. The Contractor must allow for corrective action to resolve failing items while meeting project schedule.

- E. The listings and descriptions of the inspections, tests and checks described herein shall not be considered as complete and all-inclusive. Additional normal standard construction (and sometimes repetitive) checks and tests shall be necessary throughout the job, prior to final acceptance by Owner.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS FOR INSPECTION, TESTING AND START-UP

- A. Obtain all inspections required by all laws, ordinances, rules, regulations or public authority having jurisdiction and obtain certificates of such inspections and submit same to Associate and Owner. Pay all fees, charges and other expenses in connection therein.
- B. When the Associate and Owners Representative makes final inspection of all electrical work, tests will be ordered as deemed necessary. This Contractor shall provide such assistance as required (including manpower and tools) to start and stop the various systems. This Contractor (not Owner or its representatives) is responsible to turn on the systems and demonstrate they are operating properly including any programming or final adjustments.
- C. Prepare proposed procedures and schedules for inspections, test, settings and calibrations specified or otherwise required prior to or during the checkout for start-up and acceptance of the electrical components, equipment and systems. This work shall be coordinated and shall be compatible with both the work of other crafts and the project schedule. The above must be organized and submitted with proposed testing and check out forms for the review and approval of the Owner's representative. The procedures must provide specific instructions for the checking and testing of each component in addition to the system functional checks. Tests and inspections shall also be scheduled as the job progresses and may require repetition in greater detail at a later stage of construction. Procedures submitted shall include job safety rules proposed.
- D. Equipment purchased by the Contractor or purchased by Owner for installation shall be inspected and tested to determine its condition. See other applicable sections of the specifications and contract documents for required checks and responsibilities.
- E. At any stage of construction and when observed, any electrical equipment or system determined to be damaged, faulty, or requiring repairs shall be reported. Corrective action may require prior approval.
- F. Electrical power distribution equipment and systems shall be tested in accordance with the current edition of NETA Standard's acceptance testing specification. The Contractor shall be responsible for all final settings and adjustments on protective devices and transformer tap changes.
- G. Check the continuity of all circuits to ground before they are energized. The phase wires and neutral wires shall be checked for continuity prior to the last connection made. Feeders shall be meggered for insulation abrasions in accordance to NETA testing specifications.

3.2 TESTS TO BE PERFORMED

- A. The following electrical equipment and systems shall be tested in accordance with the current edition of the NETA Acceptance Testing Specifications where installed within Project:
 - 1. Motors and related control systems.

3.3 DOCUMENTATION OF TEST RESULTS

- A. All personnel engaged in performing the above tests shall provide a signed legible letter verifying successful operation of the system(s). Attached to this letter shall be a copy of the document outlined in paragraph 3.1 with a check indicating tests performed by this individual.
- B. Any measured test data shall also be attached for future reference by the University.

END OF SECTION 260510

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SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.

B. Related Requirements:

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- A. Copper Conductors: Comply with NEMA WC 70/ICEA S-95-658.
- B. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Type THW-2 Type THHN/THWN-2 Type XHHW-2.
- C. Multiconductor Cable: Comply with NEMA WC 70/ICEA S-95-658 for metal-clad cable, Type MC with ground wire.

2.2 CONNECTORS AND SPLICES

- A. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- B. Comply with NFPA 70.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper stranded for No. 12 AWG and larger.
- B. Branch Circuits: Copper stranded for No. 12 AWG and larger, except VFC cable, which shall be extra flexible stranded.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway
- B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN/THWN-2, single conductors in raceway
- C. Exposed Branch Circuits, Including in Crawlspace: Type THHN/THWN-2, single conductors in raceway.
- D. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway. Metal-clad cable, Type MC for lighting fixture drops no longer than 6'-0".
- E. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
- B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.
- C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

- F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

3.4 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- B. Make splices, terminations, and taps that are compatible with conductor material[and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors].
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.

3.5 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."
- B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.7 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test feeder conductor for compliance with requirements.
 - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- B. Test and Inspection Reports: Prepare a written report to record the following:

- C. Cables will be considered defective if they do not pass tests and inspections.

END OF SECTION 260519

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SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes grounding and bonding systems and equipment.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

2.3 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- D. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless mechanical-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.4 GROUNDING ELECTRODES

- A. Existing to remain

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install stranded conductors for No. 12 AWG and larger unless otherwise indicated.
- B. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 - 4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

- A. Existing to remain

3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. None.

3.4 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
- C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

3.5 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage. Grounding conductors associated with feeders and branch circuits shall be run in the same conduit with the circuit conductors.

- B. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
 - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
 - 3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

3.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.

END OF SECTION 260526

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SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hangers and supports for electrical equipment and systems.

B. Related Requirements:

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents as well as accidental load.

- B. Steel Slotted Support Systems: Comply with MFMA-4 factory-fabricated components for field assembly.

1. Material: Pre-galvanized steel
2. Channel Width: 1-1/4 inches.
3. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-.
5. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
6. Channel Dimensions: Selected for applicable load criteria.

- C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

- D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

- E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.
- F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
 - 1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - 2. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
 - 3. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
 - 4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
 - 5. Toggle Bolts: All-steel springhead type.
 - 6. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems unless requirements in this Section are stricter.
- B. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
- C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as scheduled in NECA 1, where its Table 1 lists maximum spacing that are less than those stated in NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
- D. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 - 1. Secure raceways and cables to these supports with two-bolt conduit clamps

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.
- B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements.
- D. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 PAINTING

- A. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 260529

SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Metal wireways and auxiliary gutters.
3. Surface raceways.
4. Boxes, enclosures, and cabinets.

B. Related Requirements:

1.2 ACTION SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
1. Structural members in paths of conduit groups with common supports.
 2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

- A. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. GRC: Comply with ANSI C80.1 and UL 6.
- C. IMC: Comply with ANSI C80.6 and UL 1242.
- D. EMT: Comply with ANSI C80.3 and UL 797.
- E. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

- F. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
 - 1. Conduit Fittings for Hazardous Locations: Comply with UL 886 and NFPA 70.
 - 2. Fittings for EMT:
 - a. Material: Steel
 - b. Type: Compression.

2.2 METAL WIREWAYS AND AUXILIARY GUTTERS

- A. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.
 - 1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

2.3 SURFACE RACEWAYS

- A. Listing and Labeling: Surface raceways shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Surface Metal Raceways: Galvanized steel with screw-on covers complying with UL 5.

2.4 BOXES, ENCLOSURES, AND CABINETS

- A. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- B. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- C. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.
- D. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- E. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.
- F. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- G. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.

- H. Gangable boxes are prohibited.
- I. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- J. Cabinets:
 - 1. NEMA 250, Type 1 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 - 2. Hinged door in front cover with flush latch and concealed hinge.
 - 3. Key latch to match panelboards.
 - 4. Metal barriers to separate wiring of different systems and voltage.
 - 5. Accessory feet where required for freestanding equipment.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Indoors: Apply raceway products as specified below unless otherwise indicated.
 - 1. Exposed, Not Subject to Physical Damage: EMT.
 - 2. Exposed, Not Subject to Severe Physical Damage: EMT Exposed and Subject to Severe
 - 3. Physical Damage: IMC. Raceway locations include the following:
 - a. Loading dock.
 - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - c. Mechanical rooms.
 - 4. Concealed in Ceilings and Interior Walls and Partitions: EMT
 - 5. Connection to Vibrating Equipment Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment: FMC, except use LFMC in damp or wet locations.
 - 6. Damp or Wet Locations: IMC.
 - 7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 nonmetallic in institutional and commercial kitchens and damp or wet locations.
- B. Minimum Raceway Size: 3/4-inch trade size.
- C. Raceway Fittings: Compatible with raceways and suitable for use and location.
 - 1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.

2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
 3. EMT: Use setscrew steel fittings. Comply with NEMA FB 2.10.
 4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
- D. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- E. Install surface raceways only where indicated on Drawings.
- F. Do not install nonmetallic conduit.

3.2 INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
- B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- C. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- D. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- E. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.
- F. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- G. Support conduit within 12 inches of enclosures to which attached.
- H. Stub-ups to Above Recessed Ceilings:
1. Use EMT, IMC, or RMC for raceways.
 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- I. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

- J. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.
- K. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
- L. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
- M. Surface Raceways:
 - 1. Install surface raceway with a minimum 2-inch radius control at bend points.
 - 2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.
- N. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces.
- O. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
 - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 2. Where an underground service raceway enters a building or structure.
 - 3. Where otherwise required by NFPA 70.
- P. Expansion-Joint Fittings:
 - 1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet.
 - 2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
 - 3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per degree F of temperature change for PVC conduits.
 - 4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.

5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
 - Q. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semi-recessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
 1. Use LFMC in damp or wet locations subject to severe physical damage.
 2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
 - R. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to of box unless otherwise indicated.
 - S. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a rain tight connection between the box and cover plate or the supported equipment and box.
 - T. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
 - U. Locate boxes so that cover or plate will not span different building finishes.
 - V. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
 - W. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
 - X. Set metal floor boxes level and flush with finished floor surface.
- 3.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS
- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
- 3.4 FIRESTOPPING
- A. Install firestop at penetrations of fire-rated floor and wall assemblies.
- 3.5 PROTECTION
- A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

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SECTION 260535 - RACEWAY & FITTINGS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Special Conditions, General Requirements, Division 1 Specifications, apply to this Section.

1.2 DESCRIPTION

- A. Provide all raceway fittings, supports and back boxes required to complete work indicated on the Contract Documents.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Subject to general requirements and use as specified in Section 260533 "Raceway and Boxes".
- B. For fittings of specialized type, use the products as scheduled for each type under "Manufacturers," or approved equal.

2.2 MANUFACTURERS

- A. General Use Fittings: Steel City, Thomas & Betts, O.Z. Electric Manufacturing Co., Carlon, Sealing Fittings: Appleton Electric, Crouse-Hinds.
- B. Liquid-Tight Flexible Conduit Fittings: Thomas & Betts, Appleton Electric, Steel City.
- C. Expansion Fittings: O.Z. Type "DX" or approved equal of Appleton, Thomas & Betts, Crouse Hinds.
- D. Cast Metal Straight, Tee, Cross, and Fittings: Crouse-Hinds, Appleton Electric, Killark.
- E. Rigid Nonmetallic Conduit Fitting: Carlon Electrical Sciences, Inc. Cantex Industries, Hubbell.
- F. PVC coated fittings: Occidental Coating Company, Robroy Industries, Ocal (Thomas & Betts) or equal.

PART 3 - EXECUTION

3.1 USE

- A. Use threaded fittings for rigid and intermediate metal conduit.
- B. Compression or drive-on watertight fittings shall be used for metallic tubing. Fittings with set screws for trade size smaller than 2 inch is not approved for use.
- C. Fittings for flexible conduit as approved by the enforcing Code official.

- D. Use fittings made of the same material and corrosion resistance as the raceway except:
 - 1. Malleable iron and steel are interchangeable.
 - 2. Die cast fittings may be used for flexible steel conduit, and for factory manufactured offsets.
 - 3. Use insulated bushings for conduit trade sizes.
 - 4. Use steel insulated throat connectors for electrical metallic tubing.

- E. Use steel fittings that are galvanized, cadmium-plated, or have other approved protective coating.

- F. Use double locknuts for terminating rigid conduit at sheet metal enclosures and equipment conduit ends with bushings.

- G. Provide expansion fittings on every raceway larger than 1-1/2 inches, and use a 2 foot piece of seal tight on all conduit routings 1-1/2 inches and smaller where it crosses any building expansion joints. Expansion fittings shall be provided for conduit thermal expansion or contraction in accordance to tables specified in NEC. Verify exact location of building expansion joints prior to installation of raceway with project Architect.

- H. Where an expansion fitting is used, conduit bonding shall be continuous by means of a flexible braided copper bonding strap with ground clamps. Bonding strap and clamps shall be provided for grounding continuity as required by NEC. Strap shall be of sufficient length to allow full expansion. Manufacturer Crouse-Hinds XJ or XJG-EMT or approved equal.

- I. Use PVC coated fittings for rigid PVC coated steel conduit.

- J. Provide moisture barrier fittings for conduit routing entering conditioned spaces from non-conditioned spaces. This contractor shall fill fitting with an approved material preventing circulation and formations of moisture in the conduit system.

- K. Where conduit is subject to collection of condensation or moisture, provide a low point combination breather/drain such as Crouse-Hinds ECD or approved manufacturer equal.

END OF SECTION 260535

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Warning labels and signs.
5. Instruction signs.
6. Equipment identification labels, including arc-flash warning labels.
7. Miscellaneous identification products.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with ASME A13.1 and IEEE C2.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

2.2 COLOR AND LEGEND REQUIREMENTS

- A. Raceways and Cables Carrying Circuits at 600 V or Less:
1. White letters on a black field.
 2. Legend: Indicate voltage and system or service type.
- B. Warning labels and signs shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.3 LABELS

- A. Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.
 1. Preprinted, 3-mil-thick, vinyl flexible label with acrylic pressure-sensitive adhesive.
 - a. Nominal Size: 3.5-by-5-inch.

2.4 TAPES AND STENCILS:

- A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.

2.5 TAGS

- A. Nonmetallic Preprinted Tags: Polyethylene tags, 0.015 inch thick, color-coded for phase and voltage level, with factory screened permanent designations; punched for use with self-locking cable tie fastener.

2.6 SIGNS

- A. Laminated Acrylic or Melamine Plastic Signs:
 1. Engraved legend.
 2. Thickness:
 - a. For signs up to 20 sq. inches, minimum 1/16-inch thick.
 - b. For signs larger than 20 sq. inches, 1/8 inch thick.
 - c. Engraved legend with white letters on a dark grey background
 - d. Punched or drilled for mechanical fasteners.
 - e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.7 CABLE TIES

- A. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, Type 6/6 nylon.
 - 1. Minimum Width: 3/16 inch.
 - 2. Tensile Strength at 73 deg F according to ASTM D 638: 12,000 psi.
 - 3. Temperature Range: Minus 40 to plus 185 deg F.
 - 4. Color: Black, except where used for color-coding.
- B. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, self-locking.
 - 1. Minimum Width: 3/16 inch.
 - 2. Tensile Strength at 73 deg F according to ASTM D 638: 7000 psi.
 - 3. UL 94 Flame Rating: 94V-0.
 - 4. Temperature Range: Minus 50 to plus 284 deg F.
 - 5. Color: Black.

2.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- B. Apply identification devices to surfaces that require finish after completing finish work.
- C. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
- D. Attach plastic raceway and cable labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.
- E. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
 - 1. In Spaces Handling Environmental Air: Plenum rated.

3.2 IDENTIFICATION SCHEDULE

- A. Power-Circuit Conductor Identification, 600 V or Less: For conductors in, pull and junction boxes, use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use industry standard colors for ungrounded feeder and branch-circuit conductors.
 - a. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
- B. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, use self-adhesive vinyl labels with the conductor or cable designation, origin, and destination.
- C. Control-Circuit Conductor Termination Identification: For identification at terminations, provide with the conductor designation.
- D. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.
- E. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
 1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
 2. Use system of marker-tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
 3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- F. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.
 1. Limit use of underground-line warning tape to direct-buried cables.
 2. Install underground-line warning tape for direct-buried cables and cables in raceways.
- G. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- H. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels
 1. Comply with 29 CFR 1910.145.
 2. Identify system voltage with black letters on an orange background.
 3. Apply to exterior of door, cover, or other access.
 4. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:
 - a. Power-transfer switches.

- b. Controls with external control power connections.
 - I. Arc Flash Warning Labeling: Self-adhesive thermal transfer vinyl labels.
 - 1. Comply with NFPA 70E and ANSI Z535.4.
 - J. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
 - K. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
 - 1. Labeling Instructions:
 - a. Indoor Equipment: Engraved, laminated acrylic or melamine plastic label, punched or drilled for mechanical fasteners. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.
 - b. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
 - c. Unless labels are provided with self-adhesive means of attachment, fasten them with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

END OF SECTION 260553

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SECTION 262730 - TAPS, SPLICES & TERMINATIONS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Special Conditions, General Requirements, Division 1 Specifications, apply to this Section.

1.2 DESCRIPTION

- A. Provide taps, splices and termination devices approved and sized for copper cables at voltage and current rating matching characteristics of terminating conductor.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Conductors splices in No. 10 AWG and smaller wire to be made with Minnesota Mining Manufacturing Co. insulated "Scotch Locks", Ideal Co. "Wing Nut", T. & B "Piggy" connectors, or with mechanically crimped sleeves as manufactured by T & B or Ideal Company, which shall be insulated with pressure sensitive electrical tape equal to Scotch No. "33+" or No. 88. Splicing components shall be rated for copper and aluminum conductors.
- B. Conductors #8 AWG and larger shall be terminated, spliced, and tapped with Thomas & Betts color-keyed compression connector's series 54000 or equal. The manufacturers recommended tools and dies shall be used.
- C. Copper cable lug connections #8 and larger to copper bus bar mains and branches shall use copper solderless connectors having either 2-bolt cast copper clamps or compression connectors, Thomas & Betts Series 54000 with manufacturer's recommended hexagonal dies and hydraulic compression tools.
- D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- E. Connections to equipment shall be made with pressure type terminals. Stranded wire shall use spade type terminals or terminal approved for use. Connections shall contain one conductor unless otherwise rated for multiple conductors.

2.2 MANUFACTURERS

- A. 3-M
- B. O.Z.
- C. Thomas & Betts
- D. Approved manufacturer equal

2.3 WIRE LABELS

- A. Each cable or wire termination shall be identified as noted on drawings, schedules or where not indicated, label shall note applicable branch circuit, phase and/or connected equipment. Labels shall be pressure sensitive or clip on PVC type. Approved Manufacturers: Brady, 3M or approved equal.

2.4 TERMINAL BLOCKS

- A. Where terminal blocks/strips are indicated or otherwise required, provide a complete assembly of blocks/strips having each terminal equipped with two clamp type pressure lugs or two washer bead binding screws. Use terminal strips with voltage and ampere rating sufficient to carry intended loads. Provide a white marking strip along the center line of each row of terminal for identification. Use strips having plastic barriers between adjacent terminals. Provide indicated terminal quantities or otherwise required. If quantity is not indicated, provide one terminal for each conductor entering enclosure plus 20 percent spare terminals. Type or otherwise mark the identification strip to identify each connected circuit. Relate identification to wiring diagrams, panel schedules and other terminals in a logical manner, where specific identification requirements are not indicated. Under no circumstances shall more than one wire be terminated under each terminal unless rated otherwise. Use only approved type jumper to mechanically connect terminals to each other.

1. Approved Manufacturer: Allen Bradley, IIsco, Marathon or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Make taps, splices, and terminations at junction boxes, pull boxes, switches, panel boards, and any other electrical equipment, etc. Wires shall be continuous between outlet to outlet, or from panel board to the first outlet, etc.
- B. Backboxes, device boxes, fittings or junction boxes shall be suitably sized permitting adequate conductor fill capacity per Article 314 of the National Electrical Code.
- C. All taps and splices shall be fully insulated meeting minimum insulating values of wire or conductors used.
- D. After splices are mechanically secure, provide listed electrical tape to insulate splice to equal the original insulation voltage rating of the wires, or utilize Thomas & Betts heat shrinkable insulators Series H.S. If the type of connector installed provides equivalent insulation, taping may be omitted.
- E. EC shall provide and install all feeders and branch circuit wiring to all disconnect switches, equipment, controllers, motors and wiring devices. Terminations shall be in full compliance with project documents and meet the installation requirements of the manufacturer.

END OF SECTION 262830

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Fusible switches.
 - 2. Nonfusible switches.
 - 3. Enclosures.

1.3 DEFINITIONS

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

1.4 SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
 - 1. Enclosure types and details for types other than NEMA 250, Type 1.
 - 2. Current and voltage ratings.
 - 3. Short-circuit current ratings (interrupting and withstand, as appropriate).
 - 4. Include evidence of NRTL listing for series rating of installed devices.
 - 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
 - 6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.
- B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
 2. device; include selectable ranges for each type of overcurrent protective device.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA or an NRTL.
 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- B. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Comply with NFPA 70.

1.7 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
 2. Altitude: Not exceeding 6600 feet.
- B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Owner no fewer than seven days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Owner's written permission.
4. Comply with NFPA 70E.

1.8 COORDINATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

- A. Type HD, Heavy Duty, Single Throw, 600V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

2.2 NONFUSIBLE SWITCHES

- A. Type HD, Heavy Duty, Single Throw, 600V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

2.3 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
 1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
 2. Outdoor Locations: NEMA 250, Type 3R.
 3. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
 4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- B. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- D. Install fuses in fusible devices.
- E. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges.

END OF SECTION 262816