

SECTION 01 1100
SUMMARY OF THE WORK

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

- A. This Section summarizes construction operations required by the Contract Documents, defines aspects of Prime Contractor's relationship with City and lists special City requirements.

1.2 RELATED WORK SPECIFIED ELSEWHERE

- A. Applicable provisions of Bidding Requirements, Contract Requirements in Division 0 and all applicable Division 1 sections.

1.3 PROJECT DESCRIPTION

- A. The Work covers the renovation of the mechanical system for the Philadelphia Zoo's Animal Hospital located in Philadelphia, PA.

1.4 CONTRACTS

- A. Construct Work under separate Prime Contracts for: Mechanical Work and Electrical Work. The scope of Work for each Contract shall be as indicated below.

1. Incidental Work provided by one Prime Contractor but specified in a Division mainly the responsibility of a different Prime Contractor shall conform to the applicable specifications (i.e. earthwork required for Plumbing Work shall comply with the requirements of Division 2).

- B. Mechanical Work: Provide all the Work of the Contract, no matter where the information is located, except as specifically indicated to be performed by one of the other Prime Contractors.

1. Selective demolition and new construction as required for new Mechanical and Plumbing Work but only if indicated on the Demolition or Architectural Drawings. Cutting and patching required by the other Prime Contractors and not specifically indicated on the drawings are the responsibility of the respective Prime. Demolition to include the removal of the existing tower, chiller, condensing water and chilled water pumps.
2. Install access doors and panels, anchors, embedments, bolts, plates, sleeves, boxes, etc. furnished under other Contracts.
3. Provide block in g, backing, box-outs, openings, recesses, etc. required for the Work of other Contracts.
4. Provide a dumpster for the use of all Contractors.
5. Provide periodic and final cleaning of building and site.
6. Normal patching of sprayed-on fireproofing required because of the installation of Work required in other Contracts.
7. Provide control lines and elevation benchmarks at central locations for the extension by other Prime Contractors.

8. Provide temporary site perimeter fence and sidewalk cover if required.
 9. Provide temporary toilet facilities for all Contractors.
 10. Provide base flashing of roof-mounted curbs and rails.
 11. Provide painting of all surfaces and equipment exposed to view in the finished Work, regardless of which Prime Contractor provided the surface or equipment.
 12. Furnish starters and disconnects for electrical components of systems included in the Mechanical Work for installation under the Electrical Contract.
- C. Mechanical Work and Electrical Work: In addition to the Work listed under Articles D and E below, each of the two separate Prime Contractors shall provide the following:
1. All the Work including administrative and managerial procedures included in Divisions O and I, indicated to be performed by each Prime Contractor.
 2. Cutting and patching required to complete the Work of each respective Prime Contract, except where selective demolition and new construction are indicated in the General Contractors Work.
 3. Coordinate, layout and furnish to others for installation all anchors, embedments, bolts, plates, sleeves, boxes, etc. required for the Work of each respective Prime Contract.
 4. Coordinate and layout all blocking, backing, box-outs, openings, recesses, etc. required for the Work of each respective Prime Contract but located in the Work of others.
 5. Provide fireproofing of fire-rated assemblies at penetrations caused by each respective Prime Contract. Provide sealant at all other penetrations.
 6. Provide concrete housekeeping pads, bases, thrust blocks, grouting, etc. required for the Work of each respective Prime Contract.
 7. Remove trash and debris created by the Work of each respective Prime Contract to the dumpster provided by the Mechanical Contractor. Provide daily clean-up of each area in which Work of each respective Prime Contract is performed.
 8. Provide lay-out and coordination of the Work of each respective Prime Contract from control points established by the Mechanical Contractor.
 9. Provide on-site temporary office and storage facilities required for the Work of each respective Prime Contract.
 10. Provide temporary drinking water for the Work of each respective Prime Contract.
 11. Provide miscellaneous steel framing, channels, supports, bracing, hangers, etc. required for the Work of each respective Prime Contract.
 12. Provide all curbs and rails required to support roof-mounted equipment required for the Work of each respective Prime Contract. Base flashings shall be by the Mechanical Contractor. Provide counterflashing required to make watertight the installation of equipment furnished under each respective Prime Contract.
- D. Mechanical Work: All the Work indicated in the "M" series drawings and all the Work indicated in the Division 15 Specifications including the Plumbing sections, except as

specifically indicated to be performed by one of the other Prime Contractors, and as follows:

1. All the Work listed in Article C above.
 2. All the Work including administrative and managerial procedures included in Divisions O and I indicated to be the Work of this Contract.
 3. Demolition of all existing mechanical equipment and systems which is associated with and/or determined to be part of the Work of this Contract.
 4. Provide the instrumentation and controls system for the mechanical equipment specified in Sections 23 2123 and 23 6426.
 5. Furnish starters and disconnects for electrical components of systems included in the Mechanical Work for installation under the Electrical Contract.
 6. Insulate AHU-1 return ductwork.
 7. Cleaning of supply and return ductwork .
 8. 20 linear feet of 24"x24" ductwork repair or replacement.
 9. Integrate new chiller and pump set into the building automation system.
 10. Demolition of existing rooftop steel dunnage down to existing building structure . Provide temporary protection of exposed roof penetrations until new dunnage is installed and roof termination repairs are complete.
 11. Provide new steel dunnage as documented on ' A' and ' S' series drawings and associated roof repairs.
 12. Provide new guardrail and roof hatch as documented on ' A' and ' M' series drawings.
- E. Electrical Work : All the Work indicated in the "E" series drawings and all the Work indicated in the Division 16 Specifications except as specifically indicated to be performed by one of the other Prime Contractors and as follows:
1. All the Work listed in Article C above.
 2. All the Work including administrative and managerial procedures included in Divisions O and I indicated to be the Work of this Contract.
 3. Demolition of all existing electrical equipment and systems, conduit runs with wiring, boxes and devices built into existing walls, which is associated with and/or determined to part of the Work of this Contract.
 4. Install starters and disconnects furnished under other Prime Contracts.
 5. Provide the temporary lighting and power systems required in Division 1.
 6. Upgrade the existing transformer and switchboard.

1.5 CONTRACTOR'S USE OF PREMISES

- A. Prime Contractors shall limit use of the premises for Work and for storage to allow:
1. Work by others
 2. Owner occupancy

- B. The Animal Hospital is a constantly-occupied facility. During the project, the building and all of its utilities need to remain operational. Construction activities such as the switchboard work that may temporarily disrupt the normal use of the building are to be scheduled at least two weeks in advance. Work requiring a shutdown is to take place off-hours and any shutdown is limited to a maximum of four (4) hours.
- C. Coordinate use of premises with Project Coordinator
- D. Protect products stored on-site
- E. Store products to avoid interference with operations of City or other Prime Contractors
- F. Secure and pay for additional storage and work areas if required by Contractor.
- G. Do not overload structure with stored materials.

PART 2 PRODUCTS NOT USED

PART 3 EXECUTION NOT USED

3.1 - END -

END OF SECTION

SECTION 01 2300
ALTERNATES

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

- A. This Section identifies each Alternate by number and describes the basic changes to be incorporated into the Work, if that Alternate is made part of the Contract.

1.2 RELATED REQUIREMENTS SPECIFIED ELSEWHERE

- A. Applicable provisions of Bidding Requirements, Contract Requirements in Division 0 and all applicable Division 1 sections.

1.3 ADMINISTRATIVE PROCEDURES

- A. Referenced Sections of Specifications stipulate pertinent requirements for products and methods to achieve the Work stipulated under each Alternate.
- B. Coordinate pertinent related Work and modify surrounding Work as required to properly integrate the Work under each Alternate, and to provide the complete construction required by the Contract Documents.
- C. Immediately following the award of the Contract, prepare and distribute to each party involved, notification of the status of each Alternate. Indicate whether Alternates have been accepted, rejected or deferred for consideration at a later date.
- D. A "Schedule of Alternates" is included at the end of this Section. Specification Sections referenced in the Schedule contain requirements for materials and methods necessary to achieve the Work described under each Alternate. Include as part of each Alternate, miscellaneous devices, accessory objects and similar items incidental to or required for a complete installation whether or not mentioned as part of the Alternate.
- E. Award of Alternates will be made in sequential order as listed in the bid, i.e., Alternate 1 and 2 before Alternate 3 would be awarded.

1.4 DEFINITIONS

- A. Refer to Section 007200 Standard Contract Requirements.

PART 2 PRODUCTS NOT USED

PART 3 EXECUTION

3.1 SCHEDULE OF ALTERNATES

- A. Mechanical Add Alternate No. 1: Insulate exhaust ductwork for AHU-1. Remove and dispose of existing duct in situation. Inspect ductwork for damage. At Contractor's Option, execute repair or replacement of damaged sections. Contractor is to assume 20 lineal feet of ductwork requires repair or replacement. Install new exterior ductwork insulation of exhaust ductwork.
- B. GCON, Mechanical, and Electrical Add Alternate No. 2: All work shown and described in the set of drawings and specifications labeled Small Primate Holding Mechanical

Upgrades. This work includes, **but** is not limited to, the construction of a new masonry vestibule, new mechanical equipment, renovations to the existing mechanical and electrical equipment, and a new fiber optic communication line from the Small Primate Holding building to the basement of the Animal Hospital.

3.2 -END-

END OF SECTION

SECTION 01 3330
SUBMITTALS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

- A. This Section describes each Prime Contractor ' s administrative and procedural requirements for submission of shop drawings, product data, samples and other required information.

1.2 RELATED WORK SPECIFIED ELSEWHERE

- A. Applicable provisions of Bidding Requirements, Contract Requirements in Division 0 and all applicable Division 1 sections.
- B. Submittal Schedule specified in Construction Scheduling, Section 013216.

1.3 WORK WITHOUT APPROVED SUBMITTALS

- A. City may withhold payment for the value of Work installed without first obtaining approved submittals, when submittal is required by individual specification sections. Refer to section 012900 "Payment Procedures".

1.4 SHOP DRAWINGS

- A. Shop drawings are Contractor's or subcontractor's Drawings made specifically for this Project, for use in fabrication and installation.
- B. Shop drawings must show sufficient data including layout, fabrication and erection details to establish evidence of conformance with design concept and compliance with the Contract Documents. Shop drawings must show relationships with adjacent construction.
- C. Do not use reproductions of Contract Drawings as Shop Drawings unless specifically permitted in the Contract Documents.
- D. Identify details by reference to sheet and detail numbers shown on Contract Drawings and by reference to paragraphs and specification section.
- E. Orient Shop Drawings in same manner as drawings .
- F. Manufacturer's Standard Schematic Drawings
 - 1. Modify drawings to delete information that is not applicable to Project. Drawings showing information which is not applicable or unaltered standard drawings shall be returned without review.
 - 2. Add supplemental information applicable to Project.

1.5 PRODUCT DATA

- A. Manufacturer's Catalog Sheets, Brochures, Diagrams, Schedules, Performance Charts, Illustrations and Other Standard Descriptive Data.
- B. Clearly mark each copy to identify materials, products or models applicable to this Project. Submittals not marked shall be returned without review.

- C. Show colors when required for evaluation, record or other purpose. Where product data is printed in color, submit all copies in original colors as published.
- D. Show dimensions and clearances required.
- E. Show performance, characteristics and capacities.
- F. Show wiring and piping diagrams, and controls.
- G. Show by reference to paragraphs and specification section.

1.6 SAMPLES

- A. Samples: Actual samples of products proposed for use. Samples must be of sufficient size and quantity to clearly illustrate:
 - 1. Functional characteristics of product or material, with integrally related parts and attachment devices.
 - 2. Full range of color, texture and patterns.

1.7 COORDINATION

- A. Coordinate preparation and processing of submittals with performance of construction activities. Transmit each submittal sufficiently in advance of performance of related construction activities to avoid delay.
- B. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals and related activities that require sequential activity.
- C. Coordinate transmittal of different types of submittals for related elements of the Work so processing will not be delayed by the need to review submittals concurrently for coordination.
- D. The City reserves the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

1.8 SUBMISSION REQUIREMENTS

- A. Comply with Schedule of Submittals.
- B. Accompany each submission with a transmittal indicating project name, location, City's project number, referenced specification number, submission number, date, item submitted, Contractor's name, Sub-contractor, supplier or manufacturer.
 - 1. Transmittal shall include Contractor's certification that information complies with Contract Documents.
 - 2. Indicate on transmittal or on submittal deviations from Contract Documents requirements.
- C. Copies
 - 1. Submit one (1) reproducible transparency and two (2) prints of each shop drawing. Transparency will be returned to Contractor.
 - 2. Submit five (5) copies of product data. One (1) copy will be retained by Design Professional.
 - 3. For sample selections, submit one (1) set. For sample approval, submit three (3) sets. The Design Professional will retain one (1) set.

- D. Where product data is printed in color and requires color for evaluation , record , or other purpose, all copies submitted shall be in original colors as published.
- E. In addition to information required on the transmittal, submittals shall include:
 - 1. Relation to adjacent structure or materials.
 - 2. Field dimensions, clearly identified as such.
 - 3. Finishes.
 - 4. Shipping and operating weights
 - 5. Gauges, fastenings, reinforcements, welding details.
 - 6. Applicable standards, such as ASTM or Federal Specification numbers.
 - 7. A blank space, 3 inches by 10 inches for action stamp.
- F. Contractor's Review:
 - 1. Contractor shall review each submittal and indicate approval with a stamp, dated, initialed and/or signed. Review shall include but not be limited to; verification of field measurements, coordination with all trades involved and compliance with Contract Documents. The Contractor shall not be relieved of responsibility for any deviation from the requirements of the Contract Documents by the City's or Design Professional's action on submittals unless the Contractor has given specific notice of deviation at the time of submission and written approval of the specific deviation is given. The Contractor shall not be relieved from responsibility for errors or omissions in submittals by the City's or Design Professional's approval thereof.
 - 2. If Contractor does not review submittals and provide the signed approval stamp before sending them to the Design Professional, they will be returned unchecked.

1.9 SUBMISSION ROUTING

- A. Forward submittal direct to Design Professional and fax copy of transmittal letter to Project Coordinator.
- B. Design Professional will forward Submittals marked as "Approved" or Approved as Noted to Project Coordinator.
- C. Design Professional will forward Submittals marked as "Revise and Resubmit" or "Rejected" back to Contractor and will fax copy of transmittal to Project Coordinator.
- D. Project Coordinator will forward Submittals back to Contractor and will fax copy of transmittal to Design Professional.

1.10 DESIGN PROFESSIONAL'S DUTIES

- A. Review submittals within 10 working days of receipt.
- B. Review for conformance to design concept of Project and for compliance with information given in Contract Documents. Review of separate item does not constitute review of an assembly in which item functions.
- C. Affix stamp and initials or signature certifying to review of submittal.
- D. Design Professional's action on submittals will result in the making of one of the following notations with related meanings:

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1. APPROVED: The work involved may proceed, and no further submission is required.
 2. APPROVED AS NOTED: The work involved may proceed incorporating comments. Annotations do not authorize changes to Contract Sum.
 3. REVISE AND RESUBMIT: The work involved may not proceed. Submittal must be corrected and resubmitted.
 4. REJECTED: The submittal is not in accordance with the Contract Documents, and a completely new submittal is required.
- E. In the event any comment made to the Submittal results in a claim for a change in the Contract, the Project Coordinator shall be notified immediately and fabrication may not be undertaken until contract modification procedures are completed.
- 1.11 CITY'S RESPONSIBILITY
- A. Review submittals within 5 working days of receipt.
 - B. Review for compliance Contract Documents. Review of separate item does not constitute review of an assembly in which item functions.
 - C. Affix stamp and initials or signature certifying to review of submittal.
 - D. City's action on submittals will result in the making of one of the following notations with related meanings:
 1. APPROVED FOR CONSTRUCTION: The work involved may proceed, and no further submission is required.
 2. APPROVED AS NOTED: The work involved may proceed incorporating comments. Annotations do not authorize changes to Contract Sum.
 3. REVISE AND RESUBMIT: The work involved may not proceed. Submittal must be corrected and resubmitted.
- 1.12 RESUBMISSION REQUIREMENTS
- A. Identification of Changes - Clearly identify changes made from the initial submittal other than those requested by the Design Professional. The Design Professional will review only those changes requested and those identified by the Contractor.
- 1.13 DISTRIBUTION OF APPROVED SUBMITTALS
- A. Contractor shall reproduce and distribute copies of submittals having the Design Professional's and City' s stamp ("Approved" or "Approved as Noted") as required to coordinate and complete the Work and to records documents fi le .
- 1.14 SUBSTITUTIONS
- A. Substitutions submitted as a shop drawing, product data or sample will be returned without action.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

NOT USED

3.1 - END-

END OF SECTION

SECTION 02 4100
DEMOLITION

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Selective demolition of building elements for alteration purposes.

1.2 RELATED REQUIREMENTS

- A. Section 01 1000 - Summary: Limitations on Contractor's use of site and premises.
- B. Section 01 3000 - Administrative Requirements: Submittal procedures.
- C. Section 01 5000 - Temporary Facilities and Controls: Site fences, security, protective barrier s, and waste removal.
- D. Section 01 7000 - Execution and Closeout Requirements: Project conditions; protection of bench marks, survey control points, and existing construction to remain; reinstallation of removed products; temporary bracing and shoring.

1.3 DEFINITIONS

- A. Remove: Detach items from existing construction without damaging items intended for reuse.
- B. Salvage: Deliver to Owner ready for reuse.
- C. Reinstall: Prepare for reuse, and install where indicated.

1.4 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Project Record Documents: Accurately record actual locations of capped and active utilities and subsurface construction.

PART 2 PRODUCTS--NOT USED

PART 3 EXECUTION

3.1 GENERAL PROCEDURES AND PROJECT CONDITIONS

- A. Comply with other requirements specified in Section 01 7000.
- B. Comply with applicable codes and regulations for demolition operations and safety of adjacent structures and the public.
 - 1. Obtain required permits.
 - 2. Take precautions to prevent catastrophic or uncontrolled collapse of structures to be removed; do not allow worker or public access within range of potential collapse of unstable structures.
 - 3. Provide, erect, and maintain temporary barriers and security devices.

4. Conduct operations to minimize effects on and interference with adjacent structures and occupants.
 5. Do not close or obstruct roadways or sidewalks without permit.
 6. Conduct operations to minimize obstruction of public and private entrances and exits; do not obstruct required exits at any time; protect persons using entrances and exits from removal operations.
 7. Obtain written permission from owners of adjacent properties when demolition equipment will traverse, infringe upon or limit access to their property.
- C. Do not begin removal until receipt of notification to proceed from Owner.
- D. Do not begin removal until built elements to be salvaged or relocated have been removed .
- E. Protect existing structures and other elements that are not to be removed.
1. Provide bracing and shoring .
 2. Prevent movement or settlement of adjacent structures .
 3. Stop work immediately if adjacent structures appear to be in danger.
- F. Minimize production of dust due to demolition operations; do not use water if that will result in ice, flooding, sedimentation of public waterways or storm sewers, or other pollution.
- G. If hazardous materials are discovered during removal operations, stop work and notify Architect and Owner; hazardous materials include regulated asbestos containing materials, lead, PCB's, and mercury.
- H. Perform demolition in a manner that maximizes salvage and recycling of materials.
1. Dismantle existing construction and separate materials.
 2. Set aside reusable, recyclable, and salvageable materials; store and deliver to collection point or point of reuse.
- I. Partial Removal of Paving and Curbs or existing construction: Neatly saw cut at right angle to surface.

3.2 EXISTING UTILITIES

- A. Coordinate work with utility companies ; notify before starting work and comply with their requirements; obtain required permits.
- B. Protect existing utilities to remain from damage .
- C. Do not disrupt public utilities without permit from authority having jurisdiction.
- D. Do not close, shut off, or disrupt existing life safety systems that are in use without at least 7 days prior written notification to Owner.
- E. Do not close, shut off, or disrupt existing utility branches or take-offs that are in use without at least 3 days prior written notification to Owner.
- F. Locate and mark utilities to remain; mark using highly visible tags or flags, with identification of utility type; protect from damage due to subsequent construction, using substantial barricades if necessary.

- G. Remove exposed piping, valves, meters, equipment, supports, and foundations of disconnected and abandoned utilities.
- H. Prepare building demolition areas by disconnecting and capping utilities outside the demolition zone; identify and mark utilities to be subsequently reconnected, in same manner as other utilities to remain.

3.3 SELECTIVE DEMOLITION FOR ALTERATIONS

- A. Drawings showing existing construction and utilities are based on casual field observation and existing record documents only.
 - 1. Verify that construction and utility arrangements are as indicated.
 - 2. Report discrepancies to Architect before disturbing existing installation.
 - 3. Beginning of demolition work constitutes acceptance of existing conditions that would be apparent upon examination prior to starting demolition.
- B. Separate areas in which demolition is being conducted from other areas that are still occupied.
 - 1. Provide, erect, and maintain temporary dustproof partitions of construction specified in Section 01 5000.
- C. Maintain weatherproof exterior building enclosure except for interruptions required for replacement or modifications; take care to prevent water and humidity damage.
- D. Remove existing work as indicated and as required to accomplish new work.
 - 1. Remove items indicated on drawings.
- E. Services (Including but not limited to HVAC, Plumbing, Fire Protection, Electrical, and Telecommunications): Remove existing systems and equipment as indicated.
 - 1. Maintain existing active systems that are to remain in operation; maintain access to equipment and operational components.
 - 2. Where existing active systems serve occupied facilities but are to be replaced with new services, maintain existing systems in service until new systems are complete and ready for service.
 - 3. Verify that abandoned services serve only abandoned facilities before removal.
 - 4. Remove abandoned pipe, ducts, conduits, and equipment, including those above accessible ceilings; remove back to source of supply where possible, otherwise cap stub and tag with identification.
- F. Protect existing work to remain.
 - 1. Prevent movement of structure; provide shoring and bracing if necessary.
 - 2. Perform cutting to accomplish removals neatly and as specified for cutting new work.
 - 3. Repair adjacent construction and finishes damaged during removal work.
 - 4. Patch as specified for patching new work.

3.4 DEBRIS AND WASTE REMOVAL

- A. Remove debris, junk, and trash from site.

- B. Leave site in clean condition, ready for subsequent work.
- C. Clean up spillage and wind-blown debris from public and private lands.

END OF SECTION

SECTION 05 1200
STRUCTURAL STEEL FRAMING

PART 1 - GENERAL

1.1 SECTIONS INCLUDES

- A. The work of this section consists of furnishing all labor, materials, plant, equipment, transportation and services necessary to completely furnish, fabricate, erect and paint all structural steel work as shown on the drawings and as specified herein, including schedules, notes and details to show size and location of members, typical connections and type of steel required. The work includes the labor and facilities for setting and holding in accurate position all anchor bolts and leveling plates for the steel work. The anchor bolts and leveling plates will be furnished by the Steel Contractor.

1.2 REFERENCE STANDARDS:

- A. Codes and Standards: Comply with provisions of following, except as otherwise indicated:
1. AISC "Code of Standard Practice for Steel Buildings and Bridges". Adopted March 18, 2005.
 2. AISC "Specification for Structural Steel Buildings, Allowable" June 1, 1989, including supplement no. 1, 2001 and the "Commentary" and Supplements thereto as issued.
 3. AISC "Specifications for Structural Joints using ASTM A325 or A490 Bolts", June 30, 2004.
 4. AWS D1.1 "Structural Welding Code."
 5. ASTM A6 "General Requirements for Delivery of Rolled Steel Plates, Shapes, Sheet Piling and Bars for Structural use."
 6. In addition to the above, all work shall conform to the requirements of the governing building code.
 7. ASTM A36 "Specifications for Structural Steel."
 8. ASTM A992 "Standard Specification for Structural Steel Shapes."
 9. ASTM A1085 "Standard Specification for Cold-Formed Welded Carbon Steel Hollow Structural Sections (HSS)."
- B. Qualification for Welding Work:
1. Qualify welding processes and welding operators in accordance with AWS "Standard Qualification Procedure."
 2. Provide certification that welders to be employed in work have satisfactorily passed AWS qualification test within previous 12 months.
 3. If recertification of welders is required, retesting will be Contractor's responsibility.
- C. Quality Control:

1. Materials and fabrication procedures are subject to inspection and tests in the shop, and field, conducted by a qualified inspection agency. Such inspections and tests will not relieve the Contractor of responsibility for providing materials and fabrication procedures in compliance with specified requirements.
 2. Promptly remove and replace materials or fabricated components which do not apply.
- D. Design of Members and Connections:
1. All details shown as typical details apply to similar conditions, unless otherwise indicated. Verify dimensions at the site whenever possible without causing delay in the work.
 2. Promptly notify the Architect whenever design of members and connections for any portion of the structure are not clearly indicated.
- E. Provisions for Missing Information:
1. It shall be understood that the Contract Sum includes the cost of providing member connections having the same span load conditions as detailed on the drawings or required to fulfill the requirements of the construction contemplated; and/or, includes the cost of providing AISC standard members and connections used under similar conditions.
- F. Fabricator/Producer Qualifications:
1. Obtain structural steel from a competent and responsible fabricator or producer meeting the following qualifications:
 - a. Five years minimum, of satisfactory experience in designing, fabricating, shop assembling, welding, finishing, delivering, etc., structural steel comparable in magnitude and produced quality to requirements indicated for this project.
 - b. Ownership of adequate plant resources and production facilities to provide structural steel of consistent and acceptable quality.
 - c. Capacity to assume undivided responsibility for design, engineering, fabrication, finishing, etc., structural steel work, that complies with specified requirements, without delaying the progress of the work.
- G. Engineer/Surveyor Qualifications: A Professional Engineer or qualified Land Surveyor who is licensed to practice in the state of this project.
- H. Independent Engineer/Surveyor: The Engineer /Surveyor selected for any of the proposed mentioned in sub-part "Surveys" shall be a registered professional engineer or licensed land surveyor. He shall not have any interest in the Contract. He shall not be employed by the Erector/Fabricator/Contractor in laying out any work, it being intended that the surveyor's certification shall represent an independent and disinterested survey.
- I. Control of Material: Materials will not be accepted which cannot be identified with appropriate certificates of conformance and certified test reports. Test reports for material tests and analyses shall be identified with specific lots and items prior to installation.

1.3 SUBMITTALS

- A. Product Data: Submit producer's or manufacturer's specifications and installation instructions for the following products. Include laboratory test reports and other data to show compliance with specifications (including specified standards.)
1. Structural steel (each type), including certified copies of mill reports covering chemical and physical properties.
 2. High-strength bolts (each type), including nuts and washers.
 3. Structural steel primer paint.
 4. Shrinkage-resistant grout.

1.4 SHOP DRAWINGS

- A. Submit shop drawings and bills of materials including complete details and schedules for fabrication and shop assembly of members, and details, schedules, procedures and diagrams showing the sequence of erection. This contractor shall also furnish all necessary prints required by mechanical and other trades in order that they may pursue their work intelligently. Include details of the location, type, size, etc., of bolts and welds. Submit structural computations. Provide details of cuts, connections, camber, holes, and other pertinent data. Indicate welds by standard AWS symbols. Show size, length, and type of each weld. Elements of fabricated items inadvertently omitted on contract drawings shall be detailed by the fabricator and indicated on the shop drawings.
1. Design of details and connections shall be signed, stamped, and sealed by a qualified Professional Engineer, who thereby certifies preparing or supervising the preparation of the details and connections to comply with specified requirements and recognized engineering principles and practice.
 2. Drawings which accompany the Contract Documents are designated Contract Drawings. These drawings are not intended to be shop drawings.
 3. New drawings shall only be made by approved reproduction process, unless otherwise specifically acceptable to the Architect. Changes shall not be made in any drawings which have been reviewed and approved without the consent of the Architect.
 4. Match Marks: Provide a diagram showing the match marks for connecting structural parts assembled in the shop for the purpose of erecting structures true and plumb, and/or for connections.
 5. Contract Drawings shall not serve as shop drawings.
- B. Architect and Engineer's review of shop drawings will be for general considerations only. Compliance with requirements for materials fabrication and erection of structural steel is the Contractor's responsibility, including correctness, and fit of connections. The Architect and Engineer shall within reasonable time either accept the drawings or return them for revision. Drawings marked "Furnish as Corrected" may be sent to the shop after revision but must be concurrently resubmitted for review. "Rejected" or "Revise and Resubmit" drawings must be submitted and cannot be released to the shop. See General Conditions on specifications for shop drawings action definitions.
- C. These shop drawings shall be based on the design drawings and shall conform to the requirements of the current issue of the Specification for the Design, Fabrication and

Erection of Structural Steel for Buildings, of the American Institute of Steel Construction. These drawings shall give all necessary information for the fabrication, erection and painting of structural steel. The Contractor shall draw and originate his own erection plans, anchor bolt plans, details and any other drawings necessary for his work. The Engineer's drawings shall not be reproduced, copied, traced or reused for erection or detail shop drawings.

- D. Include details of cuts, connections, camber, holes, and other pertinent data. Indicate welds by standard AWS symbols, and show size, length, and type of each weld. Indicate type, location and spacing of open web joists and bridging.
- E. Architectural Clearances: No part of the steel work, such as seat stiffeners, brackets, bracing, etc. shall be permitted to interfere with architectural clearances.
- F. Job Site Set: The Contractor shall keep a complete set of shop drawings bearing the Engineer's acceptance stamp on the job site at all times subsequent to such acceptance.

1.5 DELIVERY, STORAGE AND HANDLING:

- A. Deliver materials to site at such intervals to insure uninterrupted progress of work.
- B. Deliver anchor bolts and anchorage devices, which are to be embedded in cast-in-place concrete or masonry, in ample time not to delay that work.
- C. Store materials to permit easy access for inspection and identification. Keep steel members off the ground using pallets, platforms, or other supports. Protect steel members and packaged materials from erosion and deterioration.
- D. Do not store materials on structure in a manner that might cause distortion or damage to members or supporting structures. Repair or replace damaged materials or structures as directed. The Architect reserves the right to reject any material that has been damaged because of improper storage.
- E. Bolts, Nuts: Ship small parts such as bolts, nuts, washers, pins, fillers and small connecting plates or angles, in boxes, crates and barrels. Pack bolts of each length and diameter separately. Pack loose nuts or washers of each size separately.
- F. Materials which fail to comply with specified requirements, either at the shop or project site, shall be promptly removed from the site and replaced with acceptable material, without additional cost to the Owner, and without causing delay in work.

PART 2 - PRODUCTS

2.1 MATERIALS:

- A. Metal Surfaces, General: For fabrication of all steel work use only new and unused materials which are smooth and free of surface blemishes including pitting, seam marks, roller marks, rolled trade names and roughness. Remove such blemishes by grinding, or by welding and grinding, prior to cleaning, treating and application of surface finishes.
- B. High-Strength Low-Alloy Steel: ASTM A992.
- C. Structural Steel Plates and Bars: ASTM A36, new and unused, except where other type steel is indicated.
- D. Cold-Formed Steel Tubing: ASTM A1085.

- E. Steel Pipe: ASTM A53, Type E or S, Grade B.
 - 1. Finish: Black, except where indicated to be galvanized.
- F. Anchor Bolts: ASTM F1554 grade 55 "weldable", unless otherwise indicated.
- G. High-Strength Threaded Fasteners: Heavy hexagon structural bolts, heavy hexagon nuts, and hardened washers, as follows:
 - 1. Quenched and tempered medium-carbon steel bolts, nuts and washers, complying with ASTM A325, connection type SC unless noted on drawings.
- H. Electrodes for Welding: Comply with AWS Code, E70XX electrodes.
 - 1. Filler Metal: The electrode, electrode flux combination and grade of weld metal shall conform to the appropriate AWS specification for the base metal and welding process being used or shall be as shown on the drawings or specified herein where a specific choice of AWS specification allowables is required.
 - 2. The AWS designation of the electrodes to be used shall be included in the schedule of welding procedures.
 - 3. Only low hydrogen electrodes shall be used for manual shielded metal-arc welding regardless of the thickness of the steel.
 - 4. A controlled temperature storage oven shall be used at the job site as prescribed by AWS D1.1 to maintain low moisture of low hydrogen electrodes.
- I. Structural Steel Primer Paint: TNEMEC 1099 Primer or approved equal.
- J. Galvanizing: Where steel products are specified to be galvanized, they shall be hot-dip galvanized, after fabrication, in accordance with the requirements of the applicable specifications and other requirements listed below.
 - 1. Specifications for zinc (hot-galvanized) coatings on products fabricated from rolled, dressed and forged steel shapes, plates and strip - ASTM A123.
 - 2. Specification for zinc coating (hot-dip) on iron and steel hardware - ASTM A153.
 - 3. Specification for zinc coating (hot-dip) on assembled steel products - ASTM A386.
 - 4. The zinc coating shall weigh not less than 2 ounces per square foot.
 - 5. Zinc-dust-zinc-oxide primer conforming to Military Specification MIL-P-21035 shall be applied in 2 coats for repairs to damaged surfaces after removal of loose or cracked zinc coating.

2.2 FABRICATION

- A. Shop Fabrication and Assembly: Fabricate and assemble structural assemblies in shop to greatest extent possible. Fabricate items of structural steel in accordance with AISC Specifications and as indicated on final shop drawings. Provide camber in structural members where indicated.
- B. Properly mark and match-mark materials for field assembly. Fabricate for delivery sequence which will expedite erection and minimize field handling of materials.

- C. Where finishing is required, complete assembly, including welding of units, before start of finishing operations. Provide finish surfaces of member exposed in final structure free of markings, burrs, and other defect.
- D. Connections:
1. Weld or bolt shop connections, as indicated.
 2. Bolt all connections of members with high strength bolts, except where welded connections or other connections are indicated.
 3. High-Strength Bolted Construction: Install high-strength threaded fasteners in accordance with AISC "Specification for Structural Joints using ASTM A325 or A490 Bolts" (RCRBSJ). Do not use A490 Bolts for dynamic or fluctuating loadings.
 4. Connections:
 - a. Except where otherwise noted or detailed on the drawings, connections shall conform to AISC standard double angle framed beam connections. Where a standard connection cannot be used, the connection shall be designed to provide for the reaction of maximum uniformly distributed load that the beam is capable of carrying for its span, based upon allowable unit stresses. In addition, such connections shall be designed to transmit the total reactions, moments and shears that are indicated on the drawings or can be reasonably inferred from information given on the drawings, without exceeding allowable unit stresses.
 - b. When connections are detailed on the drawings, no deviation there from shall be made without the approval of the Engineer. One-sided or other types of eccentric connections will not be permitted where two-sided connections can be made.
 - c. Bolt Holes shall be drilled or punched in accordance with AISC Specifications subject to the provisions specified herein. Holes shall be accurately centered and shall register true upon erection.
 - d. Perform reaming with twist drills or short taper reamers. Obtain the approval of the Construction Manager for hand reaming. Drifting occurring during assembly shall not distort the metal or enlarge the holes. Reaming to a larger diameter of the next standard size bolts will be allowed for slight mismatching.
 - e. After reaming ensure an accuracy which shows no offset or elongation greater than 1/32" between adjacent piles of steel, for at least 85% of the remainder of the holes having no offset or elongation greater than 1/16"; otherwise the defective pieces will be rejected.
 - f. Assembly: Contact surfaces shall be thoroughly cleaned before assembly. Assembled parts shall be brought into close contact. Drift pins shall be used only for aligning members, and shall not be used in a manner which will damage metals or enlarged or distort holes. Members requiring accurate alignment shall be provided with slotted holes and/or washers for truing up the steel as required. All finished members shall be true to line and free from twists, bends and open joints.

- g. Planning and Milling: Bearing surfaces shall be planed to true beds and abutting surfaces closely fitted. All bearing stiffeners shall be milled to give full bearing.
 - h. Tighten A325 bolts to a bolt tension no less than the proof load given in the ATSC specifications for the bolts. Remove scale, dirt, burrs and other defects liable to prevent proper seating when assembling joint surfaces, including those adjacent to washers. Clean off oil, paint, lacquer or galvanizing from contact surfaces of slip-critical type joints. Use 2 nuts on unfinished and turned bolts in tension. Use properly calibrated impact wrenches or the "Turn-of-nut" method for tightening. When tightening, place a hardened washer under the nut or bolt head whichever is the element turned in tightening. The "Snug-tight" spud wrench method shall not be used.
 - 1. Arrange bolts so that the heads show in areas exposed to public view.
5. Welded Construction:
- a. Comply with AWS Code for procedures, appearance and quality of welds, and methods used in correcting welding work.
 - b. Assemble and weld built-up sections by methods which will produce true alignment of axes without warp.
 - c. Equipment shall be of the type which will supply proper current in order that the operator may produce satisfactory welds. The welding machine shall be of 200 to 400 amperes, 25-40 volt capacity. Electrodes shall conform to the requirements of any of the E-70 series conforming to the ASTM Specification A233, or to Specification A-5-1 of the American Welding Society's latest editions. Electrodes shall be suitable for positions and other conditions of intended use as per manufacturer's instructions.
 - d. Surfaces to be welded shall be free from loose scale, rust, grease, paint or other foreign material except that mill scale that withstands a vigorous wire brushing may remain. A light-film of linseed oil may be disregarded. Joint surfaces shall be free from fins and tears.
 - 1) Temperature: No welding shall be done when the temperature of the base metal is lower than 0 deg. F. At temperatures between 0 deg.F. and 32 deg.F., the surfaces of all areas within three inches of the welded joints shall be heated to a temperature too hot to touch before welding is started.
6. Steel Wall Framing: Select members which are true and straight for fabrication of steel wall framing. Straighten as required to provide uniform, square and true members in completed wall framing.
7. Holes for Other Work:
- a. Provide holes required for securing other work to structural steel framing, and for passage of other work through steel framing members, as shown on final shop drawings.

- b. Provide threaded nuts welded to framing and other specialty items as indicated to receive other work.
- c. Cut, drill, or punch holes perpendicular to metal surfaces. Do not flame cut holes or enlarge holes by burning. Drill holes in bearing plates.

2.3 SHOPPAINTING:

- A. General: Paint shall be delivered to the shop and job in original sealed containers which shall be clearly marked with the manufacturer's name and the identifying brand, number or name. The paint shall be used as prepared by the manufacturer without thinning or other admixture unless approval is obtained **in** writing from the Engineer's office. All painting shall be done on clean, dry surfaces free of loose mill scale, rust, oil, and grease and other foreign contaminants. No painting shall be done **in** a temperature lower than 45 deg.F.
 - 1. Do not paint when the ambient temperature is lower than 45 degrees F.
 - 2. Apply paint only when the temperature of the steel and paint is above 45 degrees F. and the air temperature is not forecast to drop to 45 degrees F. or less before the paint has dried.
 - 3. Avoid painting steel which is at a temperature which can cause blistering, porosity or otherwise be detrimental to the life of the paint. When paint is applied in hot weather or in cold weather ensure that the specified thickness of paint coating is obtained.
 - 4. Do not apply paint in rain, wind, snow, fog or mist or when the steel surface temperature is below the dew point, resulting in condensation of moisture.
 - 5. Complete shop painting and ensure the paint be completely dried before shipment.
- B. Non-Painted Surfaces: Milled surfaces, areas adjacent to field welds for a distance of two inches on either side of such welds, connection areas to receive high strength bolts, the top flanges of steel members to receive field welded shear connections and members to receive spray on fireproofing, shall not be shop painted. Such areas shall be field painted as soon after field welding as practicable as specified herein for field touch-up.
- C. Surface Preparation: All steel work shall be cleaned in accordance with SSPC - SP2 Hand Tool Cleaning (remove all loose mill scale, loose rust, weld slag, flux deposits, weld spatter, dirt and other foreign material; mill scale in unbroken bubble form broken and removed; sharp projections ground smooth. Oil and grease removed by solvent).
- D. Painting: Immediately after surface preparation, apply structural steel primer paint in accordance with manufacturer's instructions and at a rate to provide a uniform dry film thickness of 2.0 mils. Use painting methods which result in full coverage of joints, corners, edges and exposed surfaces. Use two coats if necessary to establish 2.0 mil coverage.
- E. Surface inaccessible after assembly shall be given two (2) Shop coats of paint before assembly.

PART 3 -EXECUTION

3.1 INSPECTION:

- A. Erector must examine areas and conditions under which structural steel work is to be installed, and notify Construction Manager in writing of conditions detrimental to proper and timely completion of work. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to the Construction Manager. Execution of the work under this section constitutes acceptance of the base or adjoining work and other conditions as satisfactory in every respect.

3.2 ERECTION:

- A. Surveys: Employ a registered Professional Engineer or Land Surveyor, experienced in survey work, to establish permanent bench marks as shown and as necessary for accurate erection of structural steel. Check elevations of concrete and masonry bearing surfaces, and locations of anchor bolts and similar devices, before erection work proceeds, and report discrepancies to Construction Manager. Do not proceed with erection until corrections have been made, or until compensating adjustments to structural steel work have been agreed upon with Construction Manager.
- B. Temporary Shoring and Bracing: Provide temporary shoring and bracing members with connections of sufficient strength to bear imposed loads. Remove temporary members and connections when permanent members are in place and final connections are made. Provide temporary guide lines to achieve proper alignment of structures as erection proceeds.
- C. Temporary Planking: Provide temporary planking and working platforms as necessary to effectively complete work.
- D. Anchor Bolts:
1. Furnish anchor bolts and other connectors required for securing structural steel to foundations and other in-place work.
 2. Furnish templates, leveling plates and other devices as necessary for presetting bolts and other anchors to accurate locations.
 3. Setting Bases and Bearing Plates: Clean concrete and masonry bearing surfaces of bond-reducing materials and roughen to improve bond to surfaces. Clean bottom surface of base and bearing plates.
 4. Set loose and attached base plates and bearing plates for structural members on wedges or other adjusting devices. Leveling plates shall be grouted solid.
 5. Tighten anchor bolts after supported members have been positioned and plumbed. Do not remove wedges or shims, but if protruding, cut off flush with edge of base or bearing plate prior to packing with grout.
 6. Pack grout solidly between bearing surfaces and bases or plates to ensure that no voids remain. Finish exposed surfaces, protect installed materials, and allow to cure.
- E. Field Assembly:

1. Set structural frames accurately to lines and elevations indicated. Align and adjust various members forming a part of a complete frame or structure before permanently fastening. Clean bearing surfaces and other surfaces which will be in permanent contact before assembly. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.
2. Level and plumb individual members of structure within specified AISC tolerances. All work shall be within a tolerance of 1:500 for design slope, level or plumb except elevator shafts which shall conform to manufacturers requirements
3. Splice members only where indicated and accepted on shop drawings.
4. Comply with AISC Specifications for bearing, adequacy of temporary connections, alignment, and removal of paint on surfaces adjacent to field welds.
5. Do not enlarge unfair holes in members by burning or by use of drift pins, except in secondary bracing members. Ream holes that must be enlarged to admit bolts.
6. Gas Cutting: Do not use gas cutting torches in field for correcting fabrication errors in structural framing. Cutting will be permitted only on secondary members which are not under stress, as acceptable to the Architect. Finish gas-cut sections equal to a sheared appearance when permitted.
7. Touch-Up Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint. Apply paint to exposed areas with same material as used for shop painting.
 - a. Apply by brush or spray to provide a minimum dry film thickness of 2.0 mils.

3.3 FIELD QUALITY CONTROL

- A. The Owner will engage an independent City of Philadelphia certified special inspection agency to inspect high-strength bolted connections and welded connections and to perform tests and prepare test reports as required by Section 1704.3 of the Philadelphia Building Code.
- B. Testing agency shall conduct and interpret tests and state in each report whether test specimens comply with requirements, and specifically state any deviations therefrom.
- C. Provide access for testing agency to places where structural steel work is being fabricated or produced so that required inspection and testing can be accomplished.
- D. Testing agency may inspect structural steel at plant before shipment; however, the Architect reserves the right, at any time before final acceptance, to reject material not complying with specified requirements.
- E. Correct deficiencies in structural steel work which inspections and laboratory test reports have indicated to be not in compliance with requirements. Perform additional tests, at Contractor's expense, as may be necessary to reconfirm any non-compliance of original work, and as may be necessary to show compliance of corrected work.
- F. Provide the Testing Agency with the following:
 1. A complete set of approved erection drawings and shop drawings.
 2. Cutting lists, order sheets, material bills and shipping bills.

3. Information as to time and place of all rolling and shipment of material to shops.
 4. Representative sample pieces requested for testing.
 5. Full and ample means and assistance for testing all material.
 6. Proper facilities, including scaffolding, temporary work platforms, etc., for inspection of the work in the mills, shop and field.
- G. Each bolting crew and welder shall be assigned an identifying symbol and mark and all shop and field connections shall be so identified that the inspector can refer back to the crew or person making the connection.
- H. Shop inspection will consist of the following:
1. Examination of members for straightness, alignment, and camber.
 2. Checking sections for compliance with contract documents and approved shop drawings.
 3. Certification of welders.
 4. Inspection and testing of welding in accordance with contract plans and specifications.
 5. Examination of sections for proper cleaning and camber
- I. Field inspection will consist of the following:
1. Examination for proper erection of all sections; bracing; bolt fit-up; thread mutilation.
 2. Certification of welders.
 3. Inspection of testing of welding in accordance with contract plans and specifications.
 4. Inspection and testing of high-strength bolts in accordance with "Specifications for Structural Joints Using ASTM A325 or A490 Bolts", para. 6(c), 1-5. Contractor shall furnish calibrating gauge.
- J. Welding Inspection will, in general, consist of complete visual inspection, and the following:
1. Manual fillet welds - random testing (approx. 1 piece of 10) by magnetic particle.
 2. Automatic fillet welds - magnetic particle testing 1 ft of each end of all welds. (Applies to web-to-flange of plate girders. Elsewhere, 1 piece in 10 applies.)
 3. Manual groove welds - ultrasonic testing, all welds.
 4. Automatic groove welds - ultrasonic testing, 50% of all welds (25% each end); **minimum run 4 ft** for web-to-flange of plate girders.
 5. Tension welds - ultrasonic testing, all welds.
 6. Criteria for acceptance or rejection identical to criteria of acceptance or rejection of welding.
- K. Defective structures, or components, shall be removed from the work site and repaired, or replaced as acceptable to the Architect. Work relating to the repair, or replacement, of defective structures, or components, shall be done at no additional cost of the Owner.

Inspection/testing shall be repeated as required until compliance with requirements specified in this section is achieved.

- L. Inspection by the Owner's Testing Agency does not relieve the Contractor of his responsibility to perform the work and to provide the materials required.
- M. If material or workmanship is rejected by the Engineer or Owner's Testing Agency, the following procedures shall be adhered to:
 - 1. Promptly replace any and all material or workmanship which is rejected at the mill, shop or building, and without additional cost to the Owner.
 - 2. Do not remove any applied marks or tags identifying rejected steel from any members while they are on the job site, and do not reuse any steel members once they have been rejected.
 - 3. Make replacements to comply with requirements of drawings and specifications and as directed by the Engineer.
 - 4. If arrangements for replacements are not made after seven (7) days notice of rejection, Owner will have replacements made and charge cost thereof against balance of monies withheld.
 - 5. Acceptance of steel work at mill or shop, or both, will not preclude rejection, whether erected or not, if found defective in any way.
 - 6. Remove rejected steel from the site within three (3) working days from date of notice of rejection, without additional cost to the Owner.

3.4 PROCEDURES FOR DEFECTIVE OR SUBSTANDARD WELDS

- A. When defects are revealed, additional inspection by whatever method is deemed necessary by the testing laboratory shall be performed to the extent necessary to assure that the full amount of defect has been located.
- B. The Engineer may require additional examination of any welds where there is reason to question the weld quality.
- C. Defects shall be repaired using the same welding procedure as was used initially in making the weld, unless otherwise accepted by the Engineer. Examination of the repaired weld shall be by the same method that was used to reveal the defect. A second repair of a defective area shall not be made without the approval of the Engineer.
- D. In all cases where the inspector has reason to question the quality of the material or workmanship, no further work shall be done on the assembly or subassembly in question until all the necessary corrections have been made. Borderline cases shall be referred to the Engineer for disposition.
- E. All work that has been completed and inspected shall be identified with a distinguishing mark. Material or work that is not acceptable shall be designated by words such as "reject" marked directly on material of the work.
- F. Any weld which, upon examination or testing is found to be defective, shall be removed to the satisfaction of the Owner's Testing Agency and the weld shall be remade. The Contractor shall remake the welds and bear the costs of reinspection of such remade welds.

3.5 CLEANUP

- A. General requirements: Upon completion of the work, unused materials, equipment, tools, etc. shall be removed from the site. Adjacent surfaces that are damaged by work under this section shall be cleaned and repaired. Leave areas of installation, and adjacent areas, in a neat, broom clean, proper and acceptable condition.
- B. Clean-up: Materials and debris resulting from structural steel work, and from other work in connection therewith, shall not be stored on site or be allowed to accumulate on the site, exterior grade surfaces, or other parts of the project limits.
 - 1. Materials and debris shall not be placed or stored within the limits of any existing street, highway, public right-of-way, or roadway.
 - 2. Parking, loading, and operation of trucks, dumpsters, etc., on existing highways and streets shall be acceptable to local authorities having jurisdiction.
 - 3. Materials that cannot be removed daily shall be stored in areas specified by the Construction Manager.

END OF SECTION

SECTION 05 5213
PIPE AND TUBE RAILINGS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Rooftop guardrails.

1.2 RELATED REQUIREMENTS

- A. Section 01 3000 - Administrative Requirements: Submittal procedures.

1.3 REFERENCE STANDARDS

- A. AAMA 611 - Voluntary Specification for Anodized Architectural Aluminum; 2014 (2015 Errata).
- B. ASTM B241/B241M - Standard Specification for Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube; 2016.
- C. ASTM B429/B429M - Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube; 2010e1.
- D. ASTM B483/B483M - Standard Specification for Aluminum and Aluminum-Alloy Drawn Tubes for General Purpose Applications; 2013, with Editorial Revision (2014).

1.4 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Indicate profiles, sizes, connection attachments, anchorage, size and type of fasteners, and accessories.

PART 2 PRODUCTS

2.1 RAILINGS - GENERAL REQUIREMENTS

- A. Design, fabricate, and test railing assemblies in accordance with the most stringent requirements of ASTM E985 and applicable local code.
- B. Allow for expansion and contraction of members and building movement without damage to connections or members.
- C. Dimensions: See drawings for configurations and heights.
- D. Provide anchors and other components as required to attach to structure, made of same materials as railing components unless otherwise indicated; where exposed fasteners are unavoidable provide flush countersunk fasteners.
- E. Provide welding fittings to join lengths, seal open ends, and conceal exposed mounting bolts and nuts, including but not limited to elbows, T-shapes, splice connectors, flanges, escutcheons, and wall brackets.

2.2 ALUMINUM MATERIALS

- A. Aluminum Tube: Minimum wall thickness of 0.127 inch (3.2 mm); ASTM B429/B429M, ASTM B241/B241M, or ASTM B483/B483M.

- B. Welding Fittings: No exposed fasteners; cast aluminum .

2.3 FABRICATION

- A. Accurately form components to suit specific project conditions and for proper connection to building structure.
- B. Fit and shop assemble components in largest practical sizes for delivery to site.
- C. Fabricate components with joints tightly fitted and secured. Provide spigots and sleeves to accommodate site assembly and installation.
- D. Welded Joints:
 - 1. Exterior Components: Continuously seal joined pieces by intermittent welds and plastic filler. Drill condensate drainage holes at bottom of members at locations that will not encourage water in trusion.
 - 2. Interior Components: Continuously seal joined pieces by intermittent welds and plastic filler.
 - 3. Grind exposed joints flush and smooth with adjacent finish surface. Make exposed joints butt tight, flush, and hairline. Ease exposed edges to small uniform radius.

2.4 ALUMINUM FINISHES

- A. Class I Natural Anodized Finish: AAMA 611 AA-M12C22A41 Clear anodic coating not less than 0.7 mils (0.018 mm) thick.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field conditions are acceptable and are ready to receive work.

3.2 PREPARATION

- A. Apply one coat of bituminous paint to concealed aluminum surfaces that will be in contact with cementitious or dissimilar materials .

3.3 INSTALLATION

- A. Install in accordance with manufacturer's instructions .
- B. Install components plumb and level , accurately fitted, free from distortion or defects, with tight joints.
- C. Anchor railings securely to structure.
- D. Conceal anchor bolts and screws whenever possible. Where not concealed, use flush countersunk fastenings.

3.4 TOLERANCES

- A. Maximum Variation From Plumb: 1/4 inch (6 mm) per floor level , non-cumulative.
- B. Maximum Offset From True Alignment: 1/4 inch (6 mm).
- C. Maximum Out-of-Position: 1/4 inch (6 mm).

END OF SECTION

PROJECT No. 71-19-4365-01
05 5213-2
PIPE AND TUBE RAILINGS

PROJECT No. 71-19-4365-01
05 5213-3
PIPE AND TUBE RAILINGS

SECTION 06 1000
ROUGH CARPENTRY

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Rough opening framing for doors, windows , and roof openings.
- B. Roofing nailers.
- C. Preservative treated wood materials.
- D. Fire retardant treated wood materials.
- E. Miscellaneous framing and sheathing.
- F. Communications and electrical room mounting boards.

1.2 RELATED REQUIREMENTS

- A. Section 01 3000 - Administrative Requirements: Submittal procedures.
- B. Section 01 7419 - Construction Waste Management and Disposal.
- C. Section 01 7800 - Closeout Submittals

1.3 REFERENCE STANDARDS

- A. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2018.
- B. AWWA U1 - Use Category System: User Specification for Treated Wood; 2017.
- C. PS 1 - Structural Plywood; 2009.
- D. PS 20 - American Softwood Lumber Standard; 2015.

1.4 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements , for submittal procedures .
- B. Product Data: Provide technical data on fire retardant treatment, wood preservative materials and adhesives.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. General: Cover wood products to protect against moisture. Support stacked products to prevent deformation and to allow air circulation.
- B. Fire Retardant Treated Wood: Prevent exposure to precipitation during shipping, storage, or installation.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Dimension Lumber: Comply with PS 20 and requirements of specified grading agencies.

1. If no species is specified, provide any species graded by the agency specified; if no grading agency is specified, provide lumber graded by any grading agency meeting the specified requirements.
2. Grading Agency: Any grading agency whose rules are approved by the Board of Review, American Lumber Standard Committee (www.alsc.org) and who provides grading service for the species and grade specified ; provide lumber stamped with grade mark unless otherwise indicated.

2.2 DIMENSION LUMBER

- A. Sizes: Nominal sizes as indicated on drawings , S4S .
- B. Moisture Content: S-dry or MC19.
- C. Miscellaneous Framing, Blocking, Nailers, Grounds , and Furring:
 1. Lumber: S4S, No. 3 or Utility Grade.
 2. Boards: Standard or No. 3.

2.3 CONSTRUCTION PANELS

- A. Communications and Electrical Room Mounting Boards: PS 1 A-D plywood, or medium density fiberboard; 3/4 inch (19 mm) thick; flame spread index of 25 or less , smoke developed index of 450 or less, when tested in accordance with ASTM E84.
 1. Binders shall not contain urea-formaldehyde.

2.4 ACCESSORIES

- A. Fasteners and Anchors:
 1. Metal and Finish: Stainless steel for high humidity and preservative-treated wood locations , unfinished steel elsewhere .
 2. Drywall Screws: Bugle head, hardened steel, power driven type, length three times thickness of sheathing.
 3. Anchors: Toggle bolt type for anchorage to hollow masonry.

2.5 FACTORY WOOD TREATMENT

- A. Treated Lumber and Plywood: Comply with requirements of AWWA U1 - Use Category System for wood treatments determined by use categories, expected service conditions, and specific applications.
 1. Fire-Retardant Treated Wood: Mark each piece of wood with producer's stamp indicating compliance with specified requirements.
 2. Preservative-Treated Wood: Provide lumber and plywood marked or stamped by an ALSC-accredited testing agency , certifying level and type of treatment in accordance with AWWA standards.
- B. Fire Retardant Treatment:
 1. Interior Type A: AWWA U1, Use Category UCFA, Commodity Specification H, low temperature (low hygroscopic) type, chemically treated and pressure impregnated; capable of providing a maximum flame spread index of 25 when tested in accordance with ASTM E84, with no evidence of significant combustion when test is extended for an additional 20 minutes.

- a. Kiln dry wood after treatment to a maximum moisture content of 19 percent for lumber and 15 percent for plywood.
 - b. Treat rough carpentry items used in exterior walls and roof construction, including blocking and nailers .
 - c. Do not use treated wood in applications exposed to weather or where the wood may become wet.
- C. Preservative Treatment:
1. Preservative Pressure Treatment of Lumber Above Grade: AWWPA U1, Use Category UC3B, Commodity Specification A using waterborne preservative.
 - a. Kiln dry lumber after treatment to maximum moisture content of 19 percent.
 - b. Treat lumber exposed to weather.
 - c. Treat lumber in contact with masonry or concrete.
 2. Preservative Pressure Treatment of Plywood Above Grade: AWWPA U1, Use Category UC2 and UC3B, Commodity Specification F using waterborne preservative.
 - a. Kiln dry plywood after treatment to maximum moisture content of 19 percent.
 - b. Treat plywood in contact with masonry or concrete.
 3. Preservative Pressure Treatment of Lumber in Contact with Soil: AWWPA U1, Use Category UC4A, Commodity Specification A using waterborne preservative.
 - a. Preservative for Field Application to Cut Surfaces: As recommended by manufacturer of factory treatment chemicals for brush-application in the field.
 - b. Restrictions: Do not use lumber or plywood treated with chromated copper arsenate (CCA) in exposed exterior applications subject to leaching .

PART 3 EXECUTION

3.1 PREPARATION

- A. Coordinate installation of rough carpentry members specified in other sections.

3.2 INSTALLATION -GENERAL

- A. Clearly separate scrap for use on site as accessory components , including: shims , bracing, and blocking.
- B. Where treated wood is used on interior, provide temporary ventilation during and immediately after installation sufficient to remove indoor air contaminants .

3.3 BLOCKING, NAILERS, AND SUPPORTS

- A. Provide framing and blocking members as indicated or as required to support finishes, fixtures, specialty items, and trim.
- B. In framed assemblies that have concealed spaces, provide solid wood fireblocking as required by applicable local code, to close concealed draft openings between floors and between top story and roof/attic space; other material acceptable to code authorities may be used in lieu of solid wood blocking.
- C. In metal stud walls, provide continuous blocking around door and window openings for anchorage of frames, securely attached to stud framing.
- D. In walls, provide blocking attached to studs as backing and support for wall-mounted items, unless item can be securely fastened to two or more studs or other method of support is explicitly indicated.
- E. In exterior masonry walls, provide continuous blocking in cavity space around door and window openings for anchorage of frames, securely attached to masonry.
- F. Where ceiling-mounting is indicated, provide blocking and supplementary supports above ceiling, unless other method of support is explicitly indicated.

3.4 ROOF-RELATED CARPENTRY

- A. Coordinate installation of roofing carpentry with deck construction, framing of roof openings, and roofing assembly installation.

3.5 INSTALLATION OF CONSTRUCTION PANELS

- A. Communications and Electrical Room Mounting Boards: Secure with screws to studs with edges over firm bearing; space fasteners at maximum 24 inches (610 mm) on center on all edges and into studs in field of board.
 - 1. At fire-rated walls, install board over wall board indicated as part of the fire-rated assembly.
 - 2. Where boards are indicated as full floor-to-ceiling height, install with long edge of board parallel to studs.
 - 3. Install adjacent boards without gaps.

3.6 SITE APPLIED WOOD TREATMENT

- A. Apply preservative treatment compatible with factory applied treatment at site-sawn cuts, complying with manufacturer's instructions.
- B. Allow preservative to dry prior to erecting members.

3.7 CLEANING

- A. Waste Disposal: Comply with the requirements of Section 01 7419 - Construction Waste Management and Disposal.
 - 1. Comply with applicable regulations.
 - 2. Do not burn scrap on project site.
 - 3. Do not burn scraps that have been pressure treated.

4. Do not send materials treated with pentachlorophenol, CCA, or ACA to co-generation facilities or "waste-to-energy" facilities.
- B. Do not leave any wood, shavings, sawdust, etc. on the ground or buried in fill.
- C. Prevent sawdust and wood shavings from entering the storm drainage system.

END OF SECTION

SECTION 09 9113
EXTERIOR PAINTING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Surface preparation.
- B. Field application of paints.
- C. Scope: Finish exterior surfaces exposed to view, unless fully factory-finished and unless otherwise indicated, including the following:
 - 1. Exposed surfaces of steel lintels and ledge angles.
 - 2. Mechanical and Electrical:
 - a. On the roof and outdoors, paint equipment that is exposed to weather or to view, including factory-finished materials.
- D. Do Not Paint or Finish the Following Items:
 - 1. Items factory-finished unless otherwise indicated; materials and products having factory-applied primers are not considered factory finished.
 - 2. Items indicated to receive other finishes .
 - 3. Items indicated to remain unfinished.
 - 4. Fire rating labels, equipment serial number and capacity labels, and operating parts of equipment.
 - 5. Non-metallic roofing and flashing.
 - 6. Stainless steel, anodized aluminum, bronze, terne coated stainless steel, zinc, and lead.
 - 7. Marble, granite, slate, and other natural stones.
 - 8. Floors, unless specifically indicated.
 - 9. Brick , glass unit masonry, architectural concrete, cast stone, integrally colored plaster and stucco.
 - 10. Exterior insulation and finish system (EIFS).
 - 11. Glass.
 - 12. Concealed pipes, ducts, and conduits.

1.2 RELATED REQUIREMENTS

- A. Section 01 3000 - Administrative Requirements: Submittal procedures.
- B. Section 01 6000 - Product Requirements: Substitutions.
- C. Section 01 6000 - Product Requirements: Maintenance materials requirements.

1.3 REFERENCE STANDARDS

- A. 40 CFR 59, Subpart D - National Volatile Organic Compound Emission Standards for Architectural Coatings; U.S. Environmental Protection Agency; current edition.

- B. SSPC-SP 1 - Solvent Cleaning; 2015, with Editorial Revision (2016).
- C. SSPC-SP 2 - Hand Tool Cleaning; 1982, with Editorial Revision (2004).
- D. SSPC-SP 6 - Commercial Blast Cleaning; 2007.
- E. SSPC-SP 7 - Brush-Off Blast Cleaning; 2007.

1.4 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide complete list of products to be used , with the following information for each:
 - 1. Manufacturer's name , product name and/or catalog number , and general product category (e.g. "alkyd enamel").
 - 2. Cross-reference to specified paint system(s) product is to be used in; include description of each system.
 - 3. Manufacturer's installation instructions.
- C. Samples: Submit three paper "draw down" samples, 8-1/2 by 11 inches (216 by 279 mm) in size, illustrating range of colors available for each finishing product specified.
 - 1. Where sheen is specified, submit samples in only that sheen.
 - 2. Allow 30 days for approval process, after receipt of complete samples by Architect.
 - 3. Paint color submittals will not be considered until color submittals for major materials not to be painted, such as masonry, have been approved.
- D. Maintenance Data: Submit data including finish schedule showing where each product/color/finish was used , product technical data sheets, material safety data sheets (MSDS), care and cleaning instructions, touch-up procedures, repair of painted and finished surfaces, and color samples of each color and finish used.
- E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 6000 - Product Requirements, for additional provisions.
 - 2. Extra Paint and Finish Materials: 1 gallon (4 L) of each color; from the same product run, store where directed.
 - 3. Label each container with color in addition to the manufacturer's label.

1.5 FIELD CONDITIONS

- A. Do not apply materials when surface and ambient temperatures are outside the temperature ranges required by the paint product manufacturer.
- B. Follow manufacturer's recommended procedures for producing best results, including testing of substrates, moisture in substrates , and humidity and temperature limitations.
- C. Do not apply exterior paint and finishes during rain or snow, or when relative humidity is outside the humidity ranges required by the paint product manufacturer.
- D. Provide lighting level of 80 ft candles (860 lx) measured mid-height at substrate surface.

PART 2 PRODUCTS**2.1 MANUFACTURERS**

- A. Provide paints and finishes used in any individual system from the same manufacturer; no exceptions.

2.2 PAINTS AND FINISHES - GENERAL

- A. Paints and Finishes: Ready mixed, unless required to be a field-catalyzed paint.
1. Provide paints and finishes of a soft paste consistency, capable of being readily and uniformly dispersed to a homogeneous coating, with good flow and brushing properties, and capable of drying or curing free of streaks or sags.
 2. Supply each paint material in quantity required to complete entire project's work from a single production run.
 3. Do not reduce, thin, or dilute paint or finishes or add materials unless such procedure is specifically described in manufacturer's product instructions.
- B. Volatile Organic Compound (VOC) Content:
1. Provide paints and finishes that comply with the most stringent requirements specified in the following:
 - a. 40 CFR 59, Subpart D--National Volatile Organic Compound Emission Standards for Architectural Coatings.
 - b. Ozone Transport Commission (OTC) Model Rule, Architectural, Industrial, and Maintenance Coatings; www.otc.air.org; specifically:
 - 1) Opaque, Flat: 50 g/L, maximum.
 - 2) Opaque, Nonflat: 150 g/L, maximum.
 - 3) Opaque, High Gloss: 250 g/L, maximum.
 - 4) Floor Coatings: 250 g/L, maximum.
 - 5) Rust Preventative Coatings: 400 g/L, maximum.
 2. Determination of VOC Content: Testing and calculation in accordance with 40 CFR 59, Subpart D (EPA Method 24), exclusive of colorants added to a tint base and water added at project site; or other method acceptable to authorities having jurisdiction.
- C. Colors: As indicated on drawings.
1. If the selected color is from a manufacturer's color line other than the manufacturer used by the Contractor's installer, color shall be matched to the selected color.
 2. Extend colors to surface edges; colors may change at any edge as directed by Architect.

2.3 PAINT SYSTEMS - EXTERIOR

- A. Metals:

1. Two top coats and one coat primer .
2. Top Coats: 100% acrylic coating.
 - a. Products:
 - 1) Sherwin-Williams Company Pro Industrial Acrylic Semi-Gloss, B66-650 Series.
3. Primer: Self cross-linking acrylic primer.
 - a. Products:
 - 1) Sherwin-Williams Company Pro-Cryl Universal Primer, B66-310 Series.
4. Substitutions: Section 01 6000 - Product Requirements.

2.4 ACCESSORY MATERIALS

- A. Accessory Materials: Provide primers, sealers, cleaning agents, cleaning cloths, sanding materials, and clean-up materials as required for final completion of painted surfaces .
- B. Patching Material: Latex filler.
- C. Fastener Head Cover Material: Latex filler.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Do not begin application of paints and finishes until substrates have been properly prepared.
- B. Verify that surfaces are ready to receive work as instructed by the product manufacturer.
- C. Examine surfaces scheduled to be finished prior to commencement of work. Report any condition that may potentially effect proper application.
- D. Test shop-applied primer for compatibility with subsequent cover materials.

3.2 PREPARATION

- A. Clean surfaces thoroughly and correct defects prior to application.
- B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.
- C. Remove or mask surface appurtenances, including electrical plates, hardware, light fixture trim, escutcheons, and fittings, prior to preparing surfaces for finishing.
- D. Seal surfaces that might cause bleed through or staining of topcoat.
- E. Remove mildew from impervious surfaces by scrubbing with solution of tetra-sodium phosphate and bleach. Rinse with clean water and allow surface to dry.
- F. Galvanized Surfaces:
 1. Remove surface contamination and oils and wash with solvent according to SSPC-SP 1.
 2. Test for adhesion. If adhesion is poor, brush blasting according to SSPC-SP7.

3. Prepare rusted surfaces according to SSPC-SP 2.
- G. Ferrous Metal:
1. Solvent clean according to SSPC-SP 1.
 2. Shop-Primed Surfaces: Sand and scrape to remove loose primer and rust. Feather edges to make touch-up patches inconspicuous. Clean surfaces with solvent. Prime bare steel surfaces the same day.
 3. Remove rust, loose mill scale, and other foreign substances using methods recommended in writing by paint manufacturer and blast cleaning according to SSPC-SP 6 "Commercial Blast Cleaning". Protect from corrosion until coated.

3.3 APPLICATION

- A. Remove unfinished covers, grilles, covers, and access panels on mechanical and electrical components and paint separately.
- B. Apply products in accordance with manufacturer's written instructions.
- C. Do not apply finishes to surfaces that are not dry. Allow applied coats to dry before next coat is applied.
- D. Apply each coat to uniform appearance.
- E. Dark Colors and Deep Clear Colors: Regardless of number of coats specified, apply additional coats until complete hide is achieved.
- F. Sand wood and metal surfaces lightly between coats to achieve required finish.
- G. Vacuum clean surfaces of loose particles. Use tack cloth to remove dust and particles just prior to applying next coat.
- H. Reinstall electrical cover plates, hardware, light fixture trim, escutcheons, and fittings removed prior to finishing.

3.4 CLEANING

- A. Collect waste material that could constitute a fire hazard, place in closed metal containers, and remove daily from site.

3.5 PROTECTION

- A. Protect finishes until completion of project.
- B. Touch-up damaged finishes after Substantial Completion.

END OF SECTION

SECTION 230000
SUMMARY OF THE WORK HVAC AND CONTRACT REQUIREMENTS

PART 1 - GENERAL

1.1 WARRANTY

- A. All equipment furnished under this contract will include a minimum two-year warranty on parts and labor. This period of time may be overridden in the individual specification sections. Warranties will begin after Substantial Completion. The date of Substantial completion will be as set in a letter issued by the Engineer/Architect.

1.2 DEFINITIONS

- A. Provide: Means to furnish, install and make the equipment/system completely functional and operational with testing, commissioning and training.

1.3 SUMMARY

- A. Work Included: It is the intent of these specifications and the accompanying drawings that the Contractor shall, unless otherwise specified herein, furnish all labor, materials, tools, and equipment necessary to complete the installation and testing of the existing mechanical work as indicated on the drawings and described hereinafter.
- B. The Mechanical Contract shall consist of all "MD" (Mechanical Demolition) "M" (Mechanical) Drawings M0.0, MD1.0, MD2.0, M1.0, M2.0 and M4.1. Note that the Mechanical Contract will also include all associated 23000, 26000 and 27000 series specification sections.

1. Demolition Roof

- a. Drain and remove the existing cooling tower as noted on the contract drawings. Removal shall include all connecting utilities and piping as noted on Contract Drawings MD1.0 and MD2.0. Refer to structural drawings for steel removal requirements. Once tower is disconnected and removed clean existing steel for new chiller installation.
- b. Cap three existing refrigerant barrel blow off valves as noted on Contract Drawing MD1.0
- c. Remove condenser water supply and return piping from the riser curb to the cooling tower. This to include all supports, but not support curbs as they shall be reused.
- d. Remove all heat tracing for make-up line back to the source panel. This to include all associated controls.
- e. Cut and cap cooling tower make-up water supply. Cap line from basement and drain down to basement to prevent future freezing.
- f. Base Bid shall include the insulation of all the existing exhaust ductwork as noted both on Contract Drawing MD1.0 and as new work under Contract

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SUMMARY OF THE WORK HVAC AND CONTRACT REQUIREMENTS

Drawing M1.0. Prep existing (non-insulated) exhaust and notify engineer/architect of areas requiring repair. Note that as part of the base bid and as noted on contract Drawing MD1.0, 20' of average size 24"x24" ductwork shall be "repaired" in such a way to maintain a "Seal Class C" membrane. This shall be sheet metal repair and not include insulation. Repair method shall be by mechanical fasteners and mastic.

- g. Prep existing roof hatch for new hand guard as defined on Contract Drawing M1.0 Detail #1.
- h. There are (approximately) 15 duct supports (use 15 for bidding reasons) for the exhaust ductwork that will require modification and replacement. Refer to Detail 2 on Mechanical Drawing M1.0. for requirements. The existing uni-strut supports will have to be removed, but the curb is to remain and be reutilized.
- i. Remove all operational control relays and interface between the Chiller and the cooling tower. This to include all building integration to the condenser water pump and the basement JACE.

2. Demolition Basement Mechanical Room

- a. Drain the chilled water system from the entire complex. Utilize compressed air to blow out the piping to assure the moisture is removed from the piping. Note: there is approximately 20% propylene (food grade) glycol in the system and must be disposed of in an approved manner to be approved by Architect.
- b. Remove existing chilled water and condensing water pump. This to include all associated controls and accessories as noted as noted on Contract Drawing MD2.0. Note that the inertia pads both pumps are presently on will remain for the future pumps.
- c. Before chiller removal, evacuation of all R-22 refrigerant as per City of Philadelphia and Department of Environmental Protection shall be required to assure that the refrigerant is completely evacuated from the system.
- d. Remove all piping associated with chiller removal. This is noted on Contract Drawing MD2.0 Details 4 and 6.
- e. Remove existing Condenser Water Treatment tank and pumps on column behind the chilled water pump.
- f. Do not remove chiller equipment pad. It will be utilized for the future installation.
- g. Remove all condenser water piping as noted in details 1,2 and 3 on Contract Drawing MD2.0.
- h. Refer to contract Drawing MD2.0 for remaining details.
- i. All removal shall be coordinated through the Architect for actual activates at least (2) weeks before demolition can begin.

3. New Work Roof:

- a. Upon approval by Architect on areas requiring repair, begin the exhaust ductwork repair per the repair guidelines noted above and on Contract Drawing M1.0 and MD1.0. Provide a 2-week window for this repair to the Architect for review and approval.

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SUMMARY OF THE WORK HVAC AND CONTRACT REQUIREMENTS

- b. Provide a professional duct cleaner as noted in contract specifications to clean and provide access doors to all existing supply and exhaust ductwork as noted on the roof. This is to provide cleaning for the ductwork on the roof only and shall be inclusive of all supply and exhaust ductwork (noted as "E" for existing) associated with existing AHU-1. This "cleaning" shall include the provision of exterior grade access panels as noted in the contract specifications for duct cleaning.
 - c. Provide all new insulation on all (E) exhaust ductwork (after repairs) with 2" rigid insulation and Venture Clad as noted on Contract Drawing M1.0 Detail # 1.
 - d. Provide and install new "boots" and PATE roof curb as noted in Detail #3 on Contract Drawing M1.0 for both 5 and 6 inch lines to be reutilized for new chiller.
 - e. Provide new chilled water supply and return piping from existing risers (as noted above) to the new chiller as defined on contract Drawing M1.0 Detail #4. Provide all required insulation and supports as noted as well.
 - f. Provide and install new Chiller as noted on Contract Drawing M1.0 Detail #1. Note that the crane for this must be through Thackray Crane Rental, Inc. 2071 Byberry Road, Philadelphia, PA 19116-3015 Phone: 215-464-1600. NOTE: Coordination for the Chiller Installation Time line must be approved through Architect once submittal is approved.
 - g. Chiller is to be supplied and installed with a MASON INDUSTRIES inertia curb as noted on Contract Drawing M1.0 Detail #1. A detail of the chiller connection shall be submitted and approved by Architect before installation can occur.
 - h. Provide and install new riser valves as noted on Contract Drawing M1.0 Detail # 5 on both new chilled water return and supply piping.
4. New Work Basement
- a. Once the demolition is complete for the two condenser supply and return risers located in the basement to roof chase, there should be a direct and open path for the 5 and 6 inch lines from the basement to the roof. Contract requirements are to seal both lines from the basement and the roof and provide anti corrosive cleaning of the piping. Cleaning shall consist of isolating both risers, filling the riser with acidified oxalate solution, (20% oxalate in 0.1M sulphuric acid) or engineer/architect approved equal. The agent shall remain in the riser for a period of 72 hours and then removed with the pipe rinsed. The solution must be rinsed clear from the piping by contractor and then the interior pipe shall be coated with a rust inhibitor and given time to dry according to manufactures instructions. Once this is complete, the piping shall be inspected for leaks (or any other objects) any required repairs shall be outside contract requirements and shall be handled separately. Once both condenser supply and return piping is deemed clear, the pipe can be connected and ready for use as per contract requirements.
 - b. It is the Mechanical Contractors responsibility to initially drain and once complete refill the complete chilled water loop. Refill requirements shall include all venting at high points (AHU-1). Refill requirements shall be

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SUMMARY OF THE WORK HVAC AND CONTRACT REQUIREMENTS

- utilizing 20% propylene (food grade glycol). For bid purposes, provide (3) 50/50 55 gallon drums of True Guard Hale-Guard 905. Contract Requirements shall be for the provision of the glycol and filling of the system.
- c. Provide and install (2) new chilled water pumps and all noted accessories. This shall include all accessories as noted on contract drawings.
 - d. Provide and install all new chilled water supply and return piping as noted on Contract Drawing M2.0. All chilled water piping 4" or greater in the basement shall have a flanged connection, all under 4" may be grooved or threaded.
 - e. The 2 new chilled water pumps shall be mounted on the remaining inertia pads from the previous pumps.
 - f. Provide and install new VFD's on existing chiller pad (now that the chiller has been removed). Anchor supports directly onto existing pad and mount in line with servicing pump.
 - g. Provide Chilled water balancing only for the system once the fill is complete.
 - h. Provide a new control system as noted in Contract Specification Section 230900 and 230993.
 - i. Provide and install a new Bag Filter as noted on Contract Drawing M2.0 Detail #1 and noted in its own schedule. This Filter shall be connected to both the chilled water and hot water systems. Isolation valves shall protect each line separately.
 - j. Provide insulation with vapor barriers in accordance with Specification Section 230700 for all piping including the piping from and to the new bag filter.
 - k. Provide chilled water "box" insulation around both new pumps.
 - l. Install Bag Filter on remaining chiller pad.
 - m. Provide a complete cleaning of the area of construction once contract is complete such that there is no excess construction debris left.

Refer to Specification Section 011100 for further contract requirements.

C. Contract Add Alternates:

This Contract shall have the following Alternates that shall be noted on the Bid Form Documentation. Please refer to the "alternates" section for actual sequencing. The mechanical alternates are as follows:

- 1. Remove the insulation on all the supply ductwork as noted on Contract Drawing M1.0 Detail # 1. Once complete provide repairs on the SUPPLY ductwork in the same fashion/requirement as noted for the exhaust ductwork. This shall include new supports in the same method as required in the base bid for the exhaust (assume 20 supports for bid purposed) as well as per the same detail (Detail #2, Contract Drawing M1.0). All requirements for the base contract exhaust ductwork are a requirement for this alternate for the supply ductwork. The added requirement for the supply ductwork would be the removal of the existing insulation for replacement. Replacement insulation shall be the same 2" rigid with Venture Clad as for the exhaust.

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SUMMARY OF THE WORK HVAC AND CONTRACT REQUIREMENTS

2. Small Primate Holding. There is a completely separate drawing set and specifications for this project. Please refer to these for this alternate.

D. General Requirements

1. Obtain all required City of Philadelphia Permits through L&I, West District.
2. Provide Commissioning Services as noted in contract documents through the contract ATC.
3. Provide all closeout documentation including As-Builts and O&M Manuals.

It will be the responsibility of the Contractor to examine all Drawings to determine the full extent of the work. All field measurements and verifications of conditions and materials will be the obligation of the Contractor. The submission of a Proposal by the Contractor will be considered an indication that all work has been included in the Proposal. It will also be considered an indication that a thorough review of conditions, materials, and all related specifications have been investigated by the Contractor, and the results of such investigations have been included in the Contractor's Proposal.

END OF SECTION

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. HVAC demolition.
3. Equipment installation requirements common to equipment sections.
4. Supports and anchorages.

1.2 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, 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 chases.
- 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.

1.3 SUBMITTALS

- A. Welding certificates. Pipe flanges and increasers/degreasers shall be welded. All welders shall be certified as have had Local Union 420 Steamfitters' Training Center and passed. Certificates are required to be submitted to the architect before work can begin.

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 HVAC 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. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

PART 2 - PRODUCTS

2.1 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.

2.2 JOINING MATERIALS

- A. Refer to individual Division 23 piping Sections for special joining materials not listed below.

- B. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

- C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

- D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

- E. Brazing Filler Metals: AWS A5.8, BCuP Series or BAg1, unless otherwise indicated.

- F. Welding Filler Metals: Comply with AWS D10.12.

- G. Solvent Cements for Joining Plastic Piping:
 - 1. CPVC Piping: ASTM F 493.
 - 2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

PART 3 - EXECUTION

3.1 HVAC DEMOLITION

- A. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.
 - 1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - 2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
 - 3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 - 4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
 - 5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
- B. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

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. Verify final equipment locations for roughing-in.
- M. 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. 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 tape or 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.
- E. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- G. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

3.4 PIPING CONNECTIONS

- A. Make connections according to the following, unless otherwise indicated:
 - 1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - 2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.

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 HVAC 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 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.
- B. Field Welding: Comply with AWS D1.1.

3.7 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

- A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC 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.

3.8 GROUTING

- A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.
- B. Clean surfaces that will come into contact with grout.
- C. Provide forms as required for placement of grout.
- D. Avoid air entrapment during placement of grout.
- E. Place grout, completely filling equipment bases.
- F. Place grout on concrete bases and provide smooth bearing surface for equipment.
- G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 230500

SECTION 230513
COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.2 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.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.
- B. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
- B. 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.

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.

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- B. Efficiency: Energy efficient, as defined in NEMA MG 1.
- C. Service Factor: 1.15.
- D. Multispeed Motors: Variable torque.
 - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
 - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Rotor: Random-wound, squirrel cage.
- F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading, unless specifically noted otherwise.
- G. Temperature Rise: Match insulation rating.
- H. Insulation: Class F
- I. Code Letter Designation:
 - 1. Motors: Manufacturer's standard starting characteristic.
- J. Enclosure Material: Rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable Frequency Controllers:
 - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
 - 2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - 3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230513

SECTION 230523
GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Brass ball valves.
2. High-performance butterfly valves.

1.2 SUBMITTALS

A. Product Data: For each type of valve indicated.

1.3 QUALITY ASSURANCE

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance: ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Refer to HVAC valve schedule articles for applications of valves.
- B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- C. Valve Sizes: Same as upstream piping unless otherwise indicated.
- D. Valve Actuator Types:
 1. Handlever (Butterfly: lockable/Ball: non-lockable)
- E. Valves in Insulated Piping: With 2-inch (50-mm) stem extensions and extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
- F. Valve-End Connections:
 1. Flanged: With flanges according to ASME B16.1 for iron valves.

2. Threaded: With threads according to ASME B1.20.1.

2.2 BRASS BALL VALVES

A. Two-Piece, Full-Port, Brass Ball Valves with Brass Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crane Co.; Crane Valve Group; Crane Valves.
 - b. Crane Co.; Crane Valve Group; Jenkins Valves.
 - c. DynaQuip Controls.
 - d. Flow-Tek, Inc.; a subsidiary of Bray International, Inc.
 - e. Hammond Valve.
 - f. Jamesbury; a subsidiary of Metso Automation.
 - g. Jomar International, LTD.
 - h. Kitz Corporation.
 - i. Legend Valve.
 - j. Marwin Valve; a division of Richards Industries.
 - k. Milwaukee Valve Company.
 - l. NIBCO INC.
2. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig (1035 kPa).
 - c. CWP Rating: 600 psig (4140 kPa).
 - d. Body Design: Two piece.
 - e. Body Material: Forged brass.
 - f. Ends: Threaded.
 - g. Seats: PTFE or TFE.
 - h. Stem: Brass.
 - i. Ball: Chrome-plated brass.
 - j. Port: Full.

2.3 HIGH-PERFORMANCE BUTTERFLY VALVES

A. Class 300, Single-Flange, High-Performance Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
 - b. Milwaukee Valve Company.
 - c. NIBCO INC.
2. Description:

- a. Standard: MSS SP-68.
- b. CWP Rating: 720 psig (4965 kPa) at 100 deg F (38 deg C).
- c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
- d. Body Material: Carbon steel, cast iron, or ductile iron.
- e. Seat: Reinforced PTFE or metal.
- f. Stem: Stainless steel; offset from seat plane.
- g. Disc: Carbon steel.
- h. Service: Bidirectional.

2.4 EXAMINATION

- A. 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.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. 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.
- E. Do not attempt to repair defective valves; replace with new valves.

2.5 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install swing check valves for proper direction of flow and in horizontal position with hinge pin level.

2.6 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.

2.7 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valve applications are not indicated, use the following:
 - 1. Shutoff Service: Butterfly valves.
 - 2. Pump-Discharge Check Valves:
- B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

2.8 CHILLED-WATER VALVE SCHEDULE

- A. Butterfly Valve.

2.9 BAG FILTER VALVE SCHEDULE

- A. Ball Valve.

END OF SECTION 230523

SECTION 230529
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Steel pipe hangers and supports.
 - 2. Trapeze pipe hangers.
 - 3. Metal framing systems.
 - 4. Thermal-hanger shield inserts.
 - 5. Fastener systems.
 - 6. Equipment supports.

1.2 DEFINITIONS

- A. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.3 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.4 SUBMITTALS

- A. Product Data: For the following:
 - 1. Steel pipe hangers and supports.
 - 2. Thermal-hanger shield inserts.
 - 3. Powder-actuated fastener systems.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
 - 1. Trapeze pipe hangers. Include Product Data for components.
 - 2. Metal framing systems. Include Product Data for components.
 - 3. Equipment supports.
- C. Welding certificates note to Specification Section 230500.

1.5 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 STEEL PIPE HANGERS AND SUPPORTS

- A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.
- B. Manufacturers:
 - 1. AAA Technology & Specialties Co., Inc.
 - 2. Bergen-Power Pipe Supports.
 - 3. B-Line Systems, Inc.; a division of Cooper Industries.
 - 4. Carpenter & Paterson, Inc.
- C. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.
- D. Nonmetallic Coatings: Plastic coating, jacket, or liner.
- E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.2 TRAPEZE PIPE HANGERS

- A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

2.3 METAL FRAMING SYSTEMS

- A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.
- B. Manufacturers:
 - 1. B-Line Systems, Inc.; a division of Cooper Industries.
 - 2. ERICO/Michigan Hanger Co.; ERISTRUT Div.
 - 3. GS Metals Corp.
 - 4. Power-Strut Div.; Tyco International, Ltd.
 - 5. Thomas & Betts Corporation.
 - 6. Tolco Inc.
 - 7. Unistrut Corp.; Tyco International, Ltd.
- C. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.

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- D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.4 THERMAL-HANGER SHIELD INSERTS

- A. Description: 100-psig- (690-kPa-) minimum, compressive-strength insulation insert encased in sheet metal shield.
- B. Manufacturers:
 - 1. Carpenter & Paterson, Inc.
 - 2. ERICO/Michigan Hanger Co.
 - 3. PHS Industries, Inc.
 - 4. Pipe Shields, Inc.
- C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate.
- D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- F. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

- A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 - 1. Manufacturers:
 - a. Hilti, Inc.
- B. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated steel, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 - 1. Manufacturers:
 - a. Hilti, Inc.

2.6 EQUIPMENT SUPPORTS

- A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.

2.7 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

- A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use padded hangers for piping that is subject to scratching.
- F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes.
- G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following type:
 - 1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20 (DN 20 to DN 500).
- H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
 - 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.

- I. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb (340 kg).
 - b. Medium (MSS Type 32): 1500 lb (680 kg).
 - c. Heavy (MSS Type 33): 3000 lb (1360 kg).
 8. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 9. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
- J. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- K. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
 2. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
 3. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.
- L. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.
- M. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

- N. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
 - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
 - 2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.
- C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.
- D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- E. Fastener System Installation:
 - 1. Install powder-actuated fasteners in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 - 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- F. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- I. Install lateral bracing with pipe hangers and supports to prevent swaying.
- J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers.
- K. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

- L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.
- M. Insulated Piping: Comply with the following:
 - 1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.
 - 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - 4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
 - 5. Insert Material: Length at least as long as protective shield.
 - 6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make smooth bearing surface.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers.
- 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.

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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 Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

3.6 PAINTING

- A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).

END OF SECTION 230529

SECTION 230553
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Pipe labels.

1.2 SUBMITTAL

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

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: Black
3. Background Color: White
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
6. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

- B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

- C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
 - 2. Lettering Size: At least 1-1/2 inches high.

2.3 DUCT LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
- B. Letter Color: Black
- C. Background Color: White
- D. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
- F. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- G. Fasteners: Stainless-steel self-tapping screws.
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
 - 2. Lettering Size: At least 1-1/2 inches high.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

- A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed 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 inaccessible 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. Omit intermediately spaced labels.
- B. Pipe Label Color Schedule:
 - 1. Heating Water Piping:
 - a. Background Color: Black
 - b. Letter Color: White

END OF SECTION 230553

SECTION 230593
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Requirements:

1. Balancing "Chilled Water" Hydronic Piping Systems:
 - a. Constant-flow hydronic systems (NOTE: the VFD on the pumps is for balancing purposes only).
2. Section Requirements: Balancing for this system shall be only from the point where the new chilled water system attaches to the original system and not the complete building. Once this is set up, the VFD shall only modulate to maintain the flow/pressure as noted on the contract drawings. The balancing requirements shall be as follows:
 - a. The chiller CH-1.
 - b. The pumps CHP-1, CHP-2.

The flow as noted (353 GPM) must be maintained to the building (Adjustable by Owner through BAS). This requirement is not for the building, it is for the equipment being replaced only.

1.2 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. NEBB: National Environmental Balancing Bureau.
- C. TAB: Testing, adjusting, and balancing.
- D. TABB: Testing, Adjusting, and Balancing Bureau.
- E. TAB Specialist: An entity engaged to perform TAB Work.

1.3 SUBMITTALS

- A. Strategies and Procedures Plan: Within 90 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.
- B. Certified TAB reports.

1.4 QUALITY ASSURANCE

- A. TAB Contractor Qualifications: Engage a TAB entity certified by NEBB
 - 1. TAB Field Supervisor: Employee of the TAB contractor and certified by NEBB
 - 2. TAB Technician: Employee of the TAB contractor and who is certified by NEBB as a TAB technician.
- B. Certify TAB field data reports and perform the following:
 - 1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
 - 2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.
- C. TAB Report Forms: Use standard TAB contractor's forms approved by Engineer
- D. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

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.
- B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine equipment performance data pump curves.
 - 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
- F. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

- G. Examine test reports specified in individual system and equipment Sections.
- H. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.
- I. Examine system pumps to ensure absence of entrained air in the suction piping.
- J. Examine operating safety interlocks and controls on HVAC equipment.
- K. 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 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. Isolating and balancing valves are open and control valves are operational.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.
- B. Cut insulation, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 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 the approved pump flow rate. Correct variations that exceed plus or minus 5 percent.
- 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 flow-control valves for specified sequence of operation, and set at indicated flow.
 3. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
 4. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
 5. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.5 PROCEDURES FOR CONSTANT-FLOW 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.
 - a. If impeller sizes must be adjusted to achieve pump performance, obtain approval from Engineer and comply with requirements in Division 23 Section "Hydronic Pumps."
 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.
 - a. Monitor motor performance during procedures and do not operate motors in overload conditions.
 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 10 percent of design.
- B. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.
- C. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.
- D. Set calibrated balancing valves, if installed, at calculated presettings.
- E. Measure flow at all stations and adjust, where necessary, to obtain first balance.

1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
- F. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.
- G. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
1. Determine the balancing station with the highest percentage over indicated flow.
 2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
 3. Record settings and mark balancing devices.
- H. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.
- I. Measure the differential-pressure-control-valve settings existing at the conclusion of balancing.
- J. Check settings and operation of each safety valve. Record settings.

3.6 PROCEDURES FOR MOTORS

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

3.7 TOLERANCES

- A. Set HVAC system's air flow rates and water flow rates within the following tolerances:
1. Chilled-Water Flow Rate: Plus or minus 10 percent

3.8 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.

3.9 FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
 - 1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
 - 2. Include a list of instruments used for procedures, along with proof of calibration.
- B. Final Report Contents: In addition to certified field-report data, include the following:
 - 1. Pump curves.
 - 2. Manufacturers' test data.
 - 3. Field test reports prepared by system and equipment installers.
 - 4. Other information relative to equipment performance; do not include Shop Drawings and product data.
- C. General Report Data: In addition to form titles and entries, include the following data:
 - 1. Title page.
 - 2. Name and address of the TAB contractor.
 - 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 supervisor 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's name, type, size, and fittings.
 - 14. Notes to explain why certain final data in the body of reports vary from indicated values.
 - 15. Test conditions for fans and pump performance forms including the following:
 - a. Cooling coil, wet- and dry-bulb conditions.
 - b. Other system operating conditions that affect performance.

- D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
 - 1. Water and steam flow rates.
 - 2. Pipe and valve sizes and locations..
 - 3. Position of balancing devices.

3.10 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional TAB 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 TAB during near-peak summer and winter conditions.

END OF SECTION 230593

SECTION 230700
HVAC INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Insulation Materials:
 - a. Mineral fiber.
2. Insulating cements.
3. Adhesives.
4. Mastics.
5. Sealants.
6. Field-applied jackets.
7. Tapes
8. Securements.
9. Corner angles.

1.2 SUBMITTALS

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

B. Shop Drawings:

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at pipe expansion joints for each type of insulation.
3. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
4. Detail removable insulation at piping specialties, equipment connections, and access panels.
5. Detail application of field-applied jackets.
6. Detail application at linkages of control devices.
7. Detail field application for each equipment type.

C. Field quality-control reports.

1.3 QUALITY ASSURANCE

- A. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Mineral-Fiber, Preformed Pipe Insulation:
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Fibrex Insulations Inc.; Coreplus 1200.
 - b. Johns Manville; Micro-Lok.
 - c. Knauf Insulation; 1000 Pipe Insulation.
 - d. Manson Insulation Inc.; Alley-K.
 - e. Owens Corning; Fiberglas Pipe Insulation.
 2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 INSULATING CEMENTS

- A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Insulco, Division of MFS, Inc.; SmoothKote.
 - b. P. K. Insulation Mfg. Co., Inc.; PK No. 127, and Quik-Cote.
 - c. Rock Wool Manufacturing Company; Delta One Shot.

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Products, Division of ITW; CP-82.
 - b. Foster Products Corporation, H. B. Fuller Company; 85-20.
 - c. ITW TACC, Division of Illinois Tool Works; S-90/80.
 - d. Marathon Industries, Inc.; 225.
 - e. Mon-Eco Industries, Inc.; 22-25.
 - 2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- C. PVC Jacket Adhesive: Compatible with PVC jacket.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Dow Chemical Company (The); 739, Dow Silicone.
 - b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
 - c. P.I.C. Plastics, Inc.; Welding Adhesive.
 - d. Speedline Corporation; Speedline Vinyl Adhesive.
 - 2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
 - 1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Products, Division of ITW; CP-35.
 - b. Foster Products Corporation, H. B. Fuller Company; 30-90.
 - c. ITW TACC, Division of Illinois Tool Works; CB-50.
 - d. Marathon Industries, Inc.; 590.
 - e. Mon-Eco Industries, Inc.; 55-40.

2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
4. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
5. Color: White.

2.5 SEALANTS

A. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Products, Division of ITW; CP-76.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: White.
6. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.6 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Johns Manville; Zeston.
 - b. P.I.C. Plastics, Inc.; FG Series.
2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
5. Factory-fabricated tank heads and tank side panels.

2.7 TAPES

- A. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
 - b. Compac Corp.; 130.
 - c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.
 - d. Venture Tape; 1506 CW NS.
 2. Width: 2 inches (50 mm).
 3. Thickness: 6 mils (0.15 mm).
 4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
 5. Elongation: 500 percent.
 6. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

2.8 SECUREMENTS

- A. Insulation Pins and Hangers:
1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Products: Subject to compliance with requirements, provide one of the following:
 - 1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series T.
 - 2) GEMCO; Perforated Base.
 - 3) Midwest Fasteners, Inc.; Spindle.
 - b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - c. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
 - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
 2. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
 - a. Products: Subject to compliance with requirements, provide one of the following:
 - 1) GEMCO.
 - 2) Midwest Fasteners, Inc.

- B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.
- C. Wire: 0.062-inch (1.6-mm) soft-annealed, galvanized steel.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. C & F Wire.
 - b. Childers Products.
 - c. PABCO Metals Corporation.
 - d. RPR Products, Inc.

2.9 CORNER ANGLES

- A. PVC Corner Angles: 30 mils (0.8 mm) thick, minimum 1 by 1 inch (25 by 25 mm), PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

- E. Install 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. Keep insulation materials dry during application and finishing.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install 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 (100 mm) o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above ambient services, do not install insulation to the following:
 - 1. Vibration-control devices.
 - 2. Testing agency labels and stamps.
 - 3. Nameplates and data plates.
 - 4. Manholes.
 - 5. Handholes.
 - 6. Cleanouts.

3.3 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
 - 4. Seal jacket to roof flashing with flashing sealant.

3.4 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
 - 1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
 - 2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 - 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 - 4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe

- diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
 6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
 9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
 3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
 4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.5 MINERAL-FIBER INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of 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. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.6 FIELD-APPLIED JACKET INSTALLATION

- A. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
 - 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

3.7 FINISHES

- A. Equipment, and Pipe Insulation with ASJ or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.
 - 1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless-steel jackets.

3.8 FIELD QUALITY CONTROL

- A. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.9 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

3.10 INDOOR PIPING INSULATION SCHEDULE

- A. Chilled-Water Supply and Return: Insulation shall be the following:
 - 1. Mineral Fiber : 1.5 inches thick, Vapor Barrier, PVC Jacket.
- B. Bag Filter Supply and Return (Chilled and Hot Water), Insulation shall be the following:
 - 1. Mineral Fiber: 1.0" inches thick, Vapor Barrier, PVC Jacket.

3.11 OUTDOOR, FIELD-APPLIED PIPING JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. Piping, Exposed:
 - 1. PVC Jacket
- C. OUTDOOR EXHAUST AND SUPPLY (ALTERNATE) DUCTWORK:
 - 1. All exterior ductwork shall receive 2" rigid board insulation as noted on the contract drawings with Venture Clad jacketing (also as noted on Contract Drawings).

END OF SECTION 230700

SECTION 230800
COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.
- B. The Commissioning requirements as listed below shall be a requirement of the Mechanical Contractors ATC (Automatic Temperature Control) Subcontractor.
- C. The complete commissioning process shall include the following:
 - 1. Chiller CH-1
 - 2. Chilled Water Pumps CHP-1/VFD-1 and CHP-2/VFD-2
 - 3. FXPCG-1
- D. NOTE: The commissioning process shall begin at project substantial completion and shall be designed and executed by the ATC Contractor under the approval of the Project Architect.

1.2 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 (ATC Contractor).
- C. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.
- D. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.3 CONTRACTOR'S RESPONSIBILITIES

- A. Perform commissioning tests at the direction of the ATC Contractor and Project Architect.
- B. Attend construction phase controls coordination meeting.
- C. Attend testing, adjusting, and balancing review and coordination meeting.
- D. 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.

1.4 (ATC Contractor) RESPONSIBILITIES

- A. Provide Project-specific construction checklists and commissioning process test procedures for actual HVAC&R 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.

1.5 COMMISSIONING DOCUMENTATION

- A. Provide the following information to the CxA for inclusion in the commissioning plan:
 - 1. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
 - 2. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVAC&R systems, assemblies, equipment, and components to be verified and tested.
 - 3. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.
 - 4. Certificate of readiness certifying that HVAC&R systems, subsystems, equipment, and associated controls are ready for testing.
 - 5. Test and inspection reports and certificates.
 - 6. Corrective action documents.
 - 7. Verification of testing, adjusting, and balancing reports.
 - 8. All points to be trending for a minimum of two weeks in advance of startup.

1.6 SUBMITTALS

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

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

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

- B. Certify that HVAC&R 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

3.2 TESTING AND BALANCING VERIFICATION

- A. Prior to performance of testing and balancing Work, provide copies of reports, sample forms, checklists, and certificates.
- B. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the direction of the Architect/Engineer.
 - 1. The testing and balancing Contractor shall use the same instruments (by model and serial number) that were used when original data were collected.
 - 2. 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.
 - 3. Remedy the deficiency and notify the Architect 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 Architect/Engineer.
- B. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.
- 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. The CxA, testing and balancing Contractor, and HVAC&R Instrumentation and Control Contractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.
- E. Tests will be performed using design conditions whenever possible.
- F. 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.
- G. The CxA may direct that set points be altered when simulating conditions is not practical.
- H. 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.
- I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.
- J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.4 HVAC&R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. HVAC&R Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls." Assist the CxA with preparation of testing plans.
- B. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment requirements are specified in Division 23 piping Sections. HVAC&R Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:
 - 1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
 - 2. Description of equipment for flushing operations.
 - 3. Minimum flushing water velocity.
 - 4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.

- C. HVAC&R Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air, steam, and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.
- D. NOTE: Include and prepare a report and requirement for a 6 month after substantial completion follow-up with a controls system check of the systems as noted in specification section 230993 and in this specification section 1.1-C.
- E. Contract requirements include the CxA Agent (Controls Contractor) to visit the site after 6 months as noted in "E" above for a period of (2) 6 hour sessions to review and test the system as noted above.

END OF SECTION 230800

SECTION 230890
HVAC DUCT CLEANING

PART 1 - GENERAL

1.1 SUMMARY AND REQUIREMENTS

A. Membership

The HVAC system cleaning contractor shall be a member in good standing of the National Air Duct Cleaners Association (NADCA), or shall maintain membership in a nationally recognized non-profit industry organization dedicated to the cleaning of HVAC systems.

B. Certification

The HVAC system cleaning contractor shall have a minimum of one (1) Air System Cleaning Specialist (ASCS) certified by NADCA on a full time basis, or shall have staff certified by a nationally recognized certification program and organization dedicated to the cleaning of HVAC systems.

C. Supervisor Qualifications

A person certified as an ASCS by NADCA, or maintaining an equivalent certification by a nationally recognized program and organization, shall be responsible for the total work herein specified.

D. Experience

The HVAC system cleaning contractor shall submit records of experience in the field of HVAC system cleaning as requested by the Architect. Bids shall only be considered from firms which are regularly engaged in HVAC system maintenance with an emphasis on HVAC system cleaning and restoration.

E. Licensing

The HVAC system cleaning contractor shall provide proof of maintaining the proper license(s), if any, as required to perform work in this state. The HVAC system cleaning contractor shall comply with all federal, state, provincial, local, and/or Authorities Having Jurisdiction rules, regulations, and licensing requirements.

F. NADCA Standard ACR

The HVAC system cleaning contractor shall perform the services specified here in accordance with the current published NADCA Standard ACR.

1. All terms in this specification shall have their meaning defined as stated in NADCA Standard ACR.
2. NADCA Standard ACR must be followed with no modifications or deviations being allowed.

1.2 ADDITIONAL REQUIREMENTS

A. Approved Cleaning Agents

All cleaning agents shall be approved by the Zoo Management and Architect to ensure compatibility with the animals.

B. Phasing

The HVAC system cleaning contractor will never have access to the entire building without restriction. Before the commencement of work, the HVAC system cleaning contractor shall submit

a plan of phasing to be approved by both the Zoo Management and the Architect. No work shall begin until the phasing plan is approved. The phasing plan proposal shall indicate what systems and areas will be impacted by the work, and the duration of each phase.

1.3 SCOPE OF WORK

- A. The Scope of Work shall include all roof top ductwork as noted on Contract Drawing M1.0. This shall include both indicated (E) supply and exhaust ductwork. This shall also include the provision and installation of exterior rates and insulated access panels where required to perform a complete cleaning of the system.

1.4 HVAC SYSTEM ASSESSMENT AND SITE SURVEY

Prior to the commencement of any cleaning work, the HVAC system cleaning contractor shall perform an assessment of the HVAC system to determine appropriate engineering controls, safety measures, tools and equipment and cleaning methods required to satisfactorily complete the project.

A. Qualifications

The HVAC system cleaning contractor performing the assessment shall be an Air Systems Cleaning Specialist (ASCS), Certified Ventilation Inspector (CVI), or equivalent. If the HVAC system cleaning contractor is inspecting for microbial contamination they shall also be qualified (through training and experience) and licensed (where applicable by law) to determine Conditions 1, 2 and 3.

B. Work Plans

Prior to the commencement of any cleaning work, the HVAC system cleaning contractor shall provide a written work plan including the following information:

1. Scope of Work identifying which HVAC components are to be cleaned, as well as those components not included in the process, along with specific environmental engineering controls required for the workspace, and any unique requirements.
2. Means and methods of cleaning to be used on the project.
3. When applicable, the name of all firms, contractors and representatives involved with the project, along with contact information and the tasks they will be performing.
4. Project schedule outlining dates and times the work will take place and timeframe for completion. The HVAC system cleaning contractor shall be involved in determining the sequence of cleaning within the larger project in order to provide the project schedule.
5. Product submittals listing all general use and/or specific "chemical type" products and coatings specific to the project, along with Safety Data Sheets for all chemical products to be used on the project.
6. Safety plan concerns and defined responsibilities of each organization's designated representative involved with executing the plan for the duration of the project.
7. Disclaimers clearly identifying items not covered under any warranty or guarantee for the project.

1.5 ENGINEERING CONTROLS

The HVAC system cleaning contractor shall use engineering controls to ensure worker and occupant safety, and to prevent cross-contamination. The HVAC system cleaning contractor shall follow specified industry standards and guidelines specific to the project environment/facility.

A. Equipment Maintenance & Use

All HVAC system cleaning contractor equipment shall be maintained in good working order, consistent with applicable jurisdictional requirements.

1. Before any equipment is brought onto the work site it shall be cleaned and inspected to ensure that it will not introduce contaminants into the indoor environment or HVAC system.
2. All equipment shall be serviced as needed to limit possible cross-contamination from poor hygiene, and/ or unsafe operating conditions for service personnel and building occupants.
3. Any activity requiring the opening of contaminated vacuum collection equipment on-site, such as servicing or filter maintenance shall be performed in an appropriate containment area or outside of the building.
4. All collection devices, vacuums and other tools and devices shall be cleaned or sealed before relocating to different areas of the building and before removing the equipment from building.
5. Fuel-powered equipment shall be positioned in a location to prevent combustion emissions and air exhaust emissions from entering the building envelope. The HVAC system cleaning contractor shall monitor and manage location of equipment to prevent introduction of combustion emissions into the occupied space.
6. When using vacuum collection equipment exhausting within the building envelope, the HVAC system cleaning contractor shall utilize equipment fitted with HEPA filtration and the equipment shall have a collection efficiency of 99.97% at 0.3 micron particle size.

B. Disposal of Debris & Contaminated Materials

All debris removed from the HVAC System shall be disposed of in accordance with applicable federal, state, provincial and local requirements. To prevent cross-contamination, all contaminated materials removed from the HVAC system shall be properly contained prior to removal from the building. Materials deemed to be hazardous by governmental agencies shall be handled in strict accordance with any applicable local, regional or national codes.

C. Control of Product Emissions

Any application of cleaning agents or other chemicals shall be used in strict accordance with manufacturer's recommended procedures and product application instructions, including exhaust ventilation as required.

PART 2 – NOT USED

PART 3 – EXECUTION

3.0 HVAC SYSTEM CLEANING REQUIREMENTS

All cleaning and restoration procedures shall achieve the minimum level of visibly clean or the specified level of cleanliness verification as defined in the contractual documents for components within the project scope of work as defined in NADCA Standard ACR.

A. Negative Duct Pressurization

Prior to and throughout duration of the cleaning process, the HVAC system and associated air duct shall be kept at an appropriate negative pressure differential relative to the indoor non-work area. This negative pressure differential shall be maintained between the portion of the HVAC duct system being cleaned and surrounding indoor occupant spaces.

1. Under all circumstances, the HVAC system cleaning contractor shall verify pressurization differential during the project.
2. When utilizing vacuum collection equipment exhausting indoors it shall utilize HEPA filtration and the equipment shall have a collection efficiency of 99.97% at 0.3 micron particle size and be capable of retaining dislodged debris.
3. All equipment used to create negative duct pressurization that does not have HEPA filtration shall be exhausted outdoors to a location that would not allow re-entrainment.

B. Service Openings

The HVAC system cleaning contractor shall utilize service openings, as required for proper cleaning, at various points of the HVAC system for physical and mechanical entry, and inspection.

1. The HVAC system cleaning contractor shall utilize existing service openings installed in the HVAC system where possible.
2. Service openings installed into the system as needed shall not degrade the structural, thermal, or functional integrity of the system and shall comply with applicable UL, SMACNA and NFPA standards, as well as local, regional, and state codes.
3. Service openings shall be created in a manner that allows for proper closure and shall not hinder, restrict, or alter the airflow within the air duct.
4. Service opening construction materials and methods shall be in compliance with industry standards and local codes, using materials acceptable under those standards and codes.
5. The HVAC system cleaning contractor shall use duct access doors and permanent panels fabricated with materials classified for flammability and smoke spread if the material is exposed to the internal airstream.
6. All tapes used in the installation and closure of service openings shall meet the requirements of UL 181A.
7. Service panels used for closing service openings in the HVAC system shall be of an equivalent gauge or heavier so as to not compromise the structural integrity of the duct.
8. Service panels used for closing service openings shall be mechanically fastened (screwed or riveted) at maximum every 4" on center and equally spaced. The panel shall overlap the duct surfaces by a minimum of 1" on all sides.
9. Closures must be properly insulated to prevent heat loss/gain or condensation on surfaces within the system.
10. Rigid fibrous glass duct systems shall be resealed in accordance with NAIMA recommended practices. Only closure techniques that comply with UL Standard 181 or UL Standard 181A are suitable for fibrous glass duct system closures.
11. Access and closure of service openings installed in fibrous glass shall be created and closed in such a manner that there are no exposed fibrous glass edges within the system common to the airstream.
12. Any fibrous glass removed during the installation of a service opening shall be repaired or replaced with like material of the same thickness so that there are no breaks or openings that would degrade the R value, service rating or vapor/air barrier characteristics.
13. All service openings shall be closed with materials meeting UL 181 for smoke generation and flame spread.
14. All service openings capable of being re-opened for future inspection or remediation shall be clearly marked and have their location reported to the engineer in project report documents.
15. Cutting service openings into flexible duct is not permitted. Flexible duct shall be disconnected at the ends as needed for proper cleaning and inspection and shall be properly reconnected.

C. Cleaning Methods

All HVAC components included in the scope of work shall be cleaned by using a suitable agitation device to dislodge contaminants from the HVAC component surface and then capturing the contaminants with a vacuum collection device. Acceptable methods will include those which will not potentially damage the integrity of the duct, nor damage porous surface materials such as liners inside the duct or system components.

1. The included HVAC components shall be cleaned using source removal mechanical cleaning methods designed to extract contaminants from within the HVAC system and safely remove contaminants from the facility.
2. It is the HVAC system cleaning contractor's responsibility to select source removal methods

that will render the HVAC system visibly clean and capable of passing cleanliness verification methods as described in NADCA Standard ACR.

3. No cleaning method, or combination of methods, shall be used which could potentially damage components of the HVAC system or negatively alter the integrity of the system.
4. Wet cleaning, power washing, steam cleaning and any other form of wet process cleaning of HVAC system components shall not damage or result in subsequent damage to the components. Cleaning agents or water shall never be applied to electrical, fibrous glass or other porous HVAC system components.

D. Particulate Collection

All methods used shall incorporate the use of vacuum collection devices that are operated continuously during cleaning. A vacuum collection device shall be connected to the component being cleaned through a predetermined opening. The vacuum collection device must be of sufficient power to render all areas being cleaned under negative pressure, such that containment of debris and the protection of the indoor environment are assured. When the vacuum collection device is used to convey air with debris, it shall maintain a sufficient velocity and negative pressure differential in the portion of the mechanical system being cleaned.

1. All vacuum devices exhausting air inside the building shall utilize HEPA filtration and the equipment shall have a collection efficiency of 99.97% at 0.3 micron particle size, including hand-held vacuums and wet-vacuums.
2. All vacuum devices exhausting air outside the facility shall be equipped with particulate collection including adequate filtration to contain debris removed from the HVAC system. Such devices shall exhaust in a manner that will not allow contaminants to re-enter the facility. Precautions shall be taken to locate the equipment down wind and away from all air intakes and other points of entry into the building. Release of debris outdoors must not violate any outdoor environmental standards, codes or regulations.

E. Containment

Debris removed during cleaning shall be collected and precautions must be taken to ensure that debris is not otherwise dispersed outside the HVAC system during the cleaning process.

F. Controlling Odors

Measures shall be employed to control odors and/or mist vapors during the cleaning process.

G. Component Cleaning

All HVAC components included in the Scope of Work must be cleaned in accordance with NADCA Standard ACR. Cleaning methods shall be employed such that all included HVAC system components must be visibly clean as defined in NADCA Standard ACR.

H. Air Duct Systems

If air duct cleaning is included in the scope of work, the HVAC system cleaning contractor shall:

1. Clean air ducts to remove all non-adhered substances so that they are capable of passing NADCA cleanliness verification tests.
2. Access air ducts through service openings in the system that are large enough to accommodate mechanical cleaning procedures and allow for cleanliness verification.
3. Use mechanical agitation methods to remove particulate, debris, and surface contamination.
4. Capture dislodged substances with a vacuum collection device.
5. Not use any cleaning methods that will damage any HVAC components.
6. Mark the position of dampers and any air-directional mechanical devices inside the HVAC system prior to cleaning and, upon completion, restore them to their marked position.
7. Verify cleanliness after cleaning has been performed as described in NADCA Standard ACR.

I. Internally Insulated Duct System Components (e.g. Internal Duct Insulation & Sound Attenuators)

If internally insulated duct system component cleaning is included in the scope of work, the HVAC system cleaning contractor shall:

1. Use cleaning methods that will not cause damage to internal insulation or sound attenuating components and will render the system capable of passing cleanliness verification tests.
2. Clean fibrous glass duct liner or duct board present in equipment or air ducts using mechanical agitation methods to remove particulate, debris, and surface contamination.
3. Ensure the mechanical cleaning methods selected for duct liner or fibrous glass duct board shall not create abrasions, breaks, or tears to fibrous glass liner or duct board surfaces.
4. Ensure the HVAC system is under constant negative pressure when cleaning internally insulated thermal or acoustical insulation components.
5. Ensure insulated thermal or acoustical insulation components do not get wet, in accordance with applicable NADCA and NAIMA standards and recommendations.
6. Verify cleanliness after cleaning has been performed as described in NADCA Standard ACR.
7. Identify for replacement fibrous glass materials with evidence of damage, deterioration, delaminating, friable materials, biological growth, or moisture such that they cannot be restored by cleaning or resurfacing.
8. When requested or specified, be capable of remediating exposed damaged insulation in air handlers and/or ducts requiring replacement.
9. Scrape clean the base surface of all metal surfaces of the duct system that have undergone removal of degraded thermal-acoustic material such that they are free of loose, visible debris prior to installation of new insulation.
10. In the event the fibrous glass removal was due to mold contamination, clean the base surface prior to reapplying any fibrous glass insulating products in the event the fibrous glass removal was due to mold contamination.
11. In the event internal insulation materials must be replaced, ensure all materials conform to applicable industry codes and standards, including those of UL, NFPA 90-A, 90-B and SMACNA. All materials used for insulation replacement within the HVAC system shall meet or exceed the specifications of the original materials or current applicable codes. Installation of the replacement materials shall be in accordance with the manufacturer's written instructions. Installation of thermal-acoustic HVAC insulation common to the air stream shall comply with current SMACNA, NAIMA and other applicable codes and standards.
12. Following completion of the installation of replacement materials, ensure all new fibrous glass surfaces shall be capable of meeting NADCA cleanliness verification requirements.

J. Antimicrobial Agents

If the application of antimicrobial agents is included in the scope of work, products must be legally approved by the Architect for the application for which they will be used.

1. Antimicrobial agents shall only be applied if active biological growth is reasonably suspected, or where unacceptable levels of biological contamination have been verified through testing.
2. Application of any antimicrobial agents used to control the growth of biological contaminants shall be performed after the removal of surface deposits and debris.
3. When used, antimicrobial agents shall be applied in strict accordance with the manufacturer's written recommendations and EPA registration listing.

3.1 CLEANLINESS VERIFICATION

All components within the project scope of work shall achieve, at minimum, the level of visibly

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clean or the specified method of cleanliness verification defined in the contractual documents. Cleanliness verification shall be performed on specified components as described in NADCA Standard ACR.

1. Cleanliness verification will be performed immediately after HVAC system component cleaning and prior to use in operation.
2. Cleanliness verification will be determined after mechanical cleaning and before the application of any treatment or introduction of any treatment-related substance to the HVAC system, including biocidal agents and coatings.

A. Visual Inspection

Visual inspection of porous and non-porous HVAC system components shall be conducted to assess that the HVAC system is visibly clean as defined in NADCA Standard ACR or the specified method of cleanliness verification defined in the contractual documents.

1. If no contaminants are evident through visual inspection, the HVAC system shall be considered clean.
2. If visible contaminants are evident through visual inspection, those portions of the system where contaminants are visible shall be re-cleaned and subjected to re-inspection for cleanliness.

B. Surface Comparison Test (porous and non-porous surfaces)

If the Surface Comparison Test is used, it must be performed in accordance with NADCA Standard ACR.

1. If visual inspection is inconclusive or disputed, then Surface Comparison Test shall be used and must be performed in accordance with NADCA Standard ACR.
2. The HVAC system cleaning contractor shall attach a vacuum brush to a contact vacuum and the device shall be running. The testing contact vacuum shall be HEPA-filtered, capable of achieving a minimum of 80 inches of static lift (WC) and shall be fitted with a 2.5 inch round nylon brush attached to a 1.5 inch diameter vacuum hose. The HVAC system cleaning contractor shall pass the brush over the surface test area four (4) times.
3. After procedure is complete, comparison shall be made to determine if the visible characteristics of the surface have changed significantly. The HVAC component surface is considered to be clean when there is no significant visible difference in the surface characteristics.
4. If Surface Comparison Test is inconclusive, the engineer reserves the right to further verify system cleanliness through the NADCA Vacuum Test as specified in NADCA Standard ACR.

C. NADCA Vacuum Test (non-porous surfaces only)

If the NADCA Vacuum Test is used, it must be performed in accordance with NADCA Standard ACR.

1. The NADCA Vacuum Test shall be witnessed by an **engineer's** representative.
2. The HVAC system cleaning contractor shall apply NADCA Vacuum Test template to component's air side surface.
3. The HVAC system cleaning contractor shall attach the vacuum cassette with filter media to a

- calibrated air sampling pump and shall pass the open face of the filter cassette over two 2 cm x 25 cm openings within the template.
4. After procedure is complete, the cassette will be prepared and weighed to determine the amount of total debris collected on the filter media.
 5. To be considered clean, the net weight of the debris collected on the filter media shall not exceed 0.75 mg/100cm².

3.2 POST-PROJECT DOCUMENTATION

At the conclusion of the project, the HVAC system cleaning contractor shall provide documentation showing compliance with this specification for all work performed. This documentation includes the following:

1. Success of the cleaning project, as verified through visual inspection and/or cleanliness verification.
2. Photo images, HVAC plans and other supporting documents such as submittal forms for materials used and/or warranties or guarantees.
3. System areas found to be damaged and/or in need of repair.
4. A copy of the lab results, if NADCA Vacuum Test is used for cleanliness verification.
5. Chain of custody documentation, if any outside laboratories or testing agencies are used.

3.3 SUPPLEMENTAL INFORMATION

A. Applicable Standards and Publications

The following current standards and publications of the issues currently in effect form a part of this specification to the extent indicated by any reference thereto:

- (A) National Air Duct Cleaners Association (NADCA): "Assessment, Cleaning & Restoration of HVAC Systems (ACR)."
- (B) National Air Duct Cleaners Association (NADCA): "Introduction to HVAC System Cleaning Services," 2004.
- (C) Underwriters' Laboratories (UL): UL Standard 181.
- (D) American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE): Standard 62, "Ventilation for Acceptable Indoor Air Quality".
- (E) American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE): Standard 180 – "Standard Practice for Inspection and Maintenance of Commercial Building HVAC systems".
- (F) American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE): Standard 62.2-2010, "Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings".
- (G) Environmental Protection Agency (EPA): "Building Air Quality," December 1991.

- (H) Environmental Protection Agency (EPA): "Mold Remediation in Schools and Commercial Buildings", September 2008.
- (I) Sheet Metal and Air Conditioning Contractors' National Association (SMACNA): "HVAC Duct Construction Standards - Metal and Flexible," 1985.
- (J) North American Insulation Manufacturers Association (NAIMA): "Cleaning Fibrous Glass Insulated Air Duct Systems," 1993.
- (K) National Fire Protection Association (NFPA): 90-A and 90-B
- (L) Institute of Inspection Cleaning and Restoration Certification (IICRC): S520.

END OF SECTION 230890

SECTION 230900
INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.
- B. See Division 23 Section "Sequence of Operations for HVAC Controls" for further requirements that relate to this Section.

1.2 SUBMITTALS

- A. Product Data: For each control device indicated.
- B. Shop Drawings:
 - 1. Schematic flow diagrams.
 - 2. Power, signal, and control wiring diagrams.
 - 3. Details of control panel faces.
 - 4. DDC System Hardware: Wiring diagrams, schematic floor plans, and schematic control diagrams.
 - 5. Control System Software: Schematic diagrams, written descriptions, and points list.
- C. Software and firmware operational documentation.
- D. Field quality-control test reports.
- E. Operation and maintenance data.

1.3 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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Honeywell Building Solutions, Honeywell International Comfort Point Open
- B. Johnson Controls ABCS (FX/PCG Series controllers)

- C. Note that ALL controllers provided as part of this contract MUST be of single source provider.
- D. ALL manufactures noted above must provide and integrate all required points and command into the ZOO Campus Honeywell Enterprise Building Integrator (EBI) through the Zoo provided VLAN interface OR through the existing JACE portal.

2.2 CONTROL SYSTEM

- A. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems.
- B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

2.3 DDC EQUIPMENT

- A. Operator Workstation: PC-based microcomputer with minimum configuration as follows:
 - 1. The interface shall be through the Campus EBI or Campus JACE. All commands shall be passthrough. There will be no active workstation at this site.
- B. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.
 - 1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation.
 - 2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
 - a. Global communications.
 - b. Discrete/digital, analog, and pulse I/O.
 - c. Monitoring, controlling, or addressing data points.
 - d. Software applications, scheduling, and alarm processing.
 - e. Testing and developing control algorithms without disrupting field hardware and controlled environment.
- C. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.
 - 1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.

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2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
 - a. Global communications.
 - b. Discrete/digital, analog, and pulse I/O.
 - c. Monitoring, controlling, or addressing data points.
 3. Local operator interface provides for download from or upload to operator workstation.
- D. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.
1. Binary Inputs: Allow monitoring of on-off signals without external power.
 2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
 3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
 4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation
 5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA)
 6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
 7. Universal I/Os: Provide software selectable binary or analog outputs.
- E. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:
1. Output ripple of 5.0 mV maximum peak to peak.
 2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
 3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.
- F. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:
1. Minimum dielectric strength of 1000 V.
 2. Maximum response time of 10 nanoseconds.
 3. Minimum transverse-mode noise attenuation of 65 dB.
 4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.4 UNITARY CONTROLLERS

- A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.

2.5 ANALOG CONTROLLERS

- A. Step Controllers: 6- or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.
- B. Electric, Outdoor-Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range minus 10 to plus 70 deg F (minus 23 to plus 21 deg C), and single- or double-pole contacts.
- C. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.
 - 1. Single controllers can be integral with control motor if provided with accessible control readjustment potentiometer.
- D. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed from maximum to minimum of 55 percent and on-off action below minimum fan speed. Controller shall briefly apply full voltage, when motor is started, to rapidly bring motor up to minimum speed. Equip with filtered circuit to eliminate radio interference.

2.6 TIME CLOCKS

- A. Manufacturers:
 - 1. Johnson Controls Inc.
 - 2. Honeywell
- B. Seven-day, programming-switch timer with synchronous-timing motor and seven-day dial; continuously charged, nickel-cadmium-battery-driven, eight-hour, power-failure carryover; multiple-switch trippers; minimum of two and maximum of eight signals per day with two normally open and two normally closed output contacts.
- C. Solid-state, programmable time control with 8 separate programs each with up to 100 on-off operations; 1-second resolution; lithium battery backup; keyboard interface and manual override; individual on-off-auto switches for each program; 365-day calendar with 20 programmable holidays; choice of fail-safe operation for each program; system fault alarm; and communications package allowing networking of time controls and programming from PC.

2.7 ELECTRONIC SENSORS

- A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.
- B. Thermistor Temperature Sensors and Transmitters:
 - 1. Manufacturers:

- a. Kele
 - b. Honeywell
 - c. Johnson Controls
2. Accuracy: Plus or minus 0.36 deg F at calibration point.
 3. Wire: Twisted, shielded-pair cable.
 4. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches
 5. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
- C. RTDs and Transmitters:
1. Manufacturers:
 - a. BEC Controls Corporation.
 - b. Honeywell
 - c. Johnson Controls, Inc.
 2. Accuracy: Plus or minus 0.2 percent at calibration point.
 3. Wire: Twisted, shielded-pair cable.
 4. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches (64 mm).
 5. Room Sensor Cover Construction: Manufacturer's standard locking covers.
 6. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
- D. Pressure Transmitters/Transducers:
1. Manufacturers:
 - a. BEC Controls Corporation.
 - b. Johnson Controls.
 - c. Honeywell
 2. Static-Pressure Transmitter: Non-directional sensor with suitable range for expected input, and temperature compensated.
 - a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
 - b. Output: 4 to 20 mA.
 3. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig (1034-kPa) operating pressure; linear output 4 to 20 mA.

2.8 STATUS SENSORS

- A. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig (55 to 414 kPa), piped across pump.

- B. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.
- C. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.
- D. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.
- E. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

2.9 CONTROL CABLE

- A. Electronic and fiber-optic cables for control wiring shall be manufacturers standard and be plenum rated.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC Piping and Equipment."
- B. Install hydronic instrument wells, valves, and other accessories according to Division 23 Section "Hydronic Piping."
- C. Install electronic and fiber-optic cables according to Division 27 Section "Communications Horizontal Cabling."

3.2 ELECTRICAL WIRING AND CONNECTION INSTALLATION

- A. Install raceways, boxes, and cabinets according to Division 26 Section "Raceway and Boxes for Electrical Systems."
- B. Install building wire and cable according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- C. Install signal and communication cable according to Division 27 Section "Communications Horizontal Cabling."
 - 1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
 - 2. Install exposed cable in raceway.

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3. Install concealed cable in raceway.
 4. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.
 5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
 6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
 7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
- D. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.
- E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:
1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
 2. Test and adjust controls and safeties.
 3. Test calibration of controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
 4. Test each point through its full operating range to verify that safety and operating control set points are as required.
 5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
 6. Test each system for compliance with sequence of operation.
 7. Test software and hardware interlocks.
- C. DDC Verification:
1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
 2. Check instruments for proper location and accessibility.
 3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
 4. Check instrument tubing for proper fittings, slope, material, and support.
 5. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
 6. Check temperature instruments and material and length of sensing elements.
 7. Check control valves. Verify that they are in correct direction.

8. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
9. Check DDC system as follows:
 - a. Verify that DDC controller power supply is from emergency power supply, if applicable.
 - b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
 - c. Verify that spare I/O capacity has been provided.
 - d. Verify that DDC controllers are protected from power supply surges.
- D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Training shall be provided in (2) 4 hour sessions with (1) 2 hour follow -up session 6 months once substantial completion has been reached.

END OF SECTION 230900

SECTION 23 0993
SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 - GENERAL

1.1 System Requirements

- A. This system is based on a Native BACnet System either through a JCI FX-80 supervisory controller or a Honeywell IPC Controller.
- B. All sensors, power and communication wiring shall be of either Johnson or Honeywell Manufacture and be designed to work in the system through the same Protocol.
- C. Provide a complete scheduling function with 6 month memory and set point settings as noted in "Trending" below.
- D. This system shall be provided with a full building graphics package.
- E. Provide and install an ambient temperature/humidity sensor as noted below and integrate both graphically and operationally.
- I. Power: All required control systems power (low and line voltage) shall be provided as part of the ATC contract.

1.2 System Summary

- A. This Section includes control sequences for HVAC systems, subsystems, and equipment.
- B. See Division 23 Section "Instrumentation and Control for HVAC" for control equipment and devices and for submittal requirements.
- C. Note, this is a Basis of Design Honeywell Comfort Point (Branch Only) or Johnson Controls ABCS as noted in Specification Section 230900.

1.3 Specific Controls/Mechanical Contract requirements:

- A. COMPLETE new communication cabling for all new equipment (MS/TP Trunk) in and from Contract areas cabling shall be stranded, shielded and Plenum Rated. Operating Protocol shall be BACNET. Communication for all noted HVAC equipment shall be through a new communication line throughout the school as noted on the contract drawings. Building Supervisory Controller shall be a CPO-PC-6A (Honeywell) or FX-80 (Johnson Controls ABCS) as noted on Contract Drawings. The controller shall be provided with Dual Drivers (BACNET) and dual trunk connections. The controller shall be the central system controller and shall be mounted as noted on Contract Drawings.
- B. The supervisory controller shall integrate an MS/TP Bus around the building to pick up and integrate all noted controller as described below.

- C. The supervisory controller shall be provided with full scheduling, monitoring and trending capabilities (Trending of up to 24 points for a 12-month period of time).
- D. Control Contractor shall provide all control meters and sensors. MC shall install all wells for sensors.
- E. Contract requirements must provide for 16 hours of system training for system operations
- F. Contract requirements require all the points listed below under “Display” be sourced and mapped through the server and graphically represented with building backgrounds.
- G. All units shall be labeled individually on the graphical interface and all indexed references.
- H. NEW Network Engine shall be web enabled for Ethernet integration. Coordinate with owner on coordination requirements (addressable IP, integration requirements etc). Owner shall bring connection to 10/100 Mb Ethernet port. Mechanical Contractor to assign/program IP and integrate server to Client Ethernet.
- I. All noted controllers are a contract requirement. It is the responsibility of the Mechanical Contractor to provide 120/24V control transformers and all required communication and low voltage power wiring to all required equipment. Each “exposed” controller shall be provided with a transformer and NEMA 1 enclosure “Clamshell” and shall be mounted above the ceiling or in storage and janitorial areas near the serviced equipment.
- J. All sensors and wiring shall be of the same manufacture and be designed to work in the system through the same Protocol.
- K. NOTE: all communication cabling (MS/TP) trunk exterior to building (Existing AHU-1/New CH-1) shall be encased in rigid aluminum conduit until termination point.

1.4 Contract Requirements Control Contractor:

- A. Provide and install a supervisory controller in the location as noted on Contract Drawing M4.1. ATC Contractor shall provide 120/24V transformer and use power as available at existing FX enclosure.
- B. Provide and install a new MS/TP communications bus to communicate between the following:
 - 1. CH-1
 - 2. VFD-1
 - 3. VFD-2
 - 4. FXPCG-1 (at switch board)
 - 5. FXPCG-2 (at Onicon F-1200)
 - 6. Small Mammal Chilled Water Circulation Pump Relay.
 - 7. Outdoor Temperature/Humidity Sensor (Hx67x3 Series Transmitter temperature /humidity)
- C. Sequence of Operations (CH-1): The Sequence of operations for this system shall include the Chiller (CH-1), circulation pumps (CHP-1 and CHP-2).

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SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

1. Upon a command from items 7, 8, 9 or owner interface command for cooling the following will occur:
 - a. A command will be sent the lead VFD (1 or 2) to enable.
 - b. A flow positive signal (4 to 20ma) is proven through the Onicon Flow sensor.
 - c. A reading shall be brought in through the ambient sensor indicating that the exterior temperature is greater than 45 degrees F.
 - d. If b and c above are proven an "enable" command will be sent the CH-1 through the BACnet interface.
 - e. The chiller shall enable. The chiller will send a signal to the "pump" for enable as part of its internal operation. This signal (24v) will be accepted by the BMS through either the export file or the local FXPCG (1 or 2).
 - f. The chiller shall go through its internal start sequence and with no alarms enable.
 - g. Temperature through chiller shall be set to a discharge or 45 degrees F through the BACnet interface. This is adjustable through the FX-80.
 - h. The chiller shall operate until an internal alarm or a command signal to disable from b or c above or the from the cooling "demand" requirements as listed above.

- D. Sequence of Operations (CHP-1 and 2): These pumps shall operate in the "Primary/Back-up" mode such that upon command as noted above, the lead pump shall enable and ramp to a balanced set point (353 GPM) as monitored by the Onicon Flow Sensor provided and installed under this contract. If a failure alarm is imported through the operating VFD or the flow sensor is indicating no or insufficient flow. The Primary pump will disable through VFD command and the BACK-UP pump shall enable through VFD command. An alarm will be sent back through the FX-80 to alarm the owner of the issue.
 1. Pump control shall be through the FX-80 with speed and enable/disable functionality.
 2. Pump control shall also monitor outdoor temperature such that if the temperature falls below 35 degrees F, the primary pump shall enable to a preset flow (120 gpm) to act as freeze protection.
 3. Pump control shall be completely through the controlling VFD with no Pump interface.
 4. Pump operational flow control shall be through the flow sensor.
 5. VFD specific Alarm signal shall be imported through the FX-80 for owner notification.

- E. FXPCG-1 (Switch Board): Upon activation of the emergency generator through a signal from the switch board imported into FXPCG-1 the following will occur:
 1. If the outdoor temperature is below 65 degrees F (Adjustable) the Small Mammal line circulation pump shall enable and an alarm will be sent through the FX-80 to notify the owner of an "Alarm Condition"
 2. NOTE: the FX-80 shall be programmed such that the monthly (or weekly) emergency generator test will not enable the pump but will still alert the owner through the FX-80 interface.

- F. FXPCG-2 (at Onicon F-1200): This controller is simply a monitoring unit that shall monitor flow (4 to 20ma) and chilled water supply and return temperatures that operate in conjunction with the systems noted above. Contract requirements require the following for FXPCG-2:
 1. Provide and install an Onicon F-1200 flow sensor as noted on drawings. ATC to provide required 24V power from FX Panel.
 2. Provide and install an insertion temperature sensor in both the building supply and return piping from the chiller.

- G. Small Mammal Chilled Water Circulation Pump Relay: There is a small pump in the line between the chilled water supply and a connecting line (pipe) that goes to the Small Mammal Holding building. This enables the chilled water coil in the case of a power outage at Small Mammal. This only operates under alarm conditions with the operation of the emergency generator and in conjunction with the fiber optic signal between the switchboard and the FX-60 in Small Mammal (to be installed under a Contract Alternate).
- H. AHU-1,2 and 3 Enable Signals: Utilize either FXPCG-1 or 2 to integrate a cooling command signal to the new FX-80 that will, (under the right circumstances as listed above) enable a "Chilled Water Plant" enable signal.
- I. Outdoor Temperature/Humidity Sensor (Hx67x3 Series Transmitter temperature/humidity): This connection serves only in the Read only mode for information in enabling the sequences as noted above.

NOTE: AHU 1 through 3 require communication interface with the new ATC system. Present protocol is N2, so a Y1/Y2 or integrated command to pull in the "cooling" command of any of those units is a contract requirement.

NOTE: Provide a current switch on the Small Mammal Emergency Pump to monitor operation.

- 1.5 FX-80 integration Points: The following are point that shall be graphically indicated through the newly installed BACNET Protocol FX-80 through to the owner interface screen.

- 1. CH-1 FX-80 readable points
 - a. DDC system graphic.
 - b. DDC system on-off indication.
 - c. Outdoor-air-temperature indication.
 - d. Chiller "enable/disable" command status.
 - e. Chilled water supply temperature set point
 - f. Chilled water supply actual temperature
 - g. Chilled water return temperature actual temperature
 - h. Unit Fault Status (alarm specific) note: pull all alarms in through FX-80 and chiller export file for owner information. Assume 15 points..
 - i. Chiller independent "pump command" status.
- 2. CH-1 FX-80 writable points:
 - a. All set points required for operation and adjustment of the points noted above.
 - b. Seasonal Operational Schedule and associated temperature set points.
 - c. Chiller Enable/Disable.
 - d. Alarm acknowledgement (software).
- 3. CHP (VFD-1 and VFD-2) FX-80 Readable Points
 - a. DDC system graphic.
 - b. DDC system specific pump on-off indication.

- c. VFD specific speed (Hz)
 - d. VFD specific command speed (Hz)
 - e. VFD (pump) Primary/Back-up Status.
 - f. Pump Primary/Back-up Schedule (initially set to weekly switch over)
 - g. Pump switch over trip speed (GPM)
 - h. Unit Fault Status (alarm specific) note: pull all alarms in through FX-80 and VFD export file for owner information. Assume 3 points.
 - i. VFD “pump command” status.
4. CHP (VFD-1 and VFD-2) FX-80 writable Points
- a. All set points required for operation and adjustment of the points noted above.
 - b. Primary Schedule
 - c. Alarm acknowledgement
 - d. Pump Speed.
 - e. Pump enable/disable.
 - f. Pump “Trip Speed”
5. FXPCG-1 FX-80 Readable Points
- a. DDC system graphic.
 - b. DDC system switch board signal status
 - c. Command signal from AHU 1 through 3 (if monitoring)
 - d. Emergency Small Mammal Pump enable status.
 - e. Small Mammal Pump Current Switch Prove Status.
6. FXPCG-1 FX-80 writable Points
- a. Small Mammal Pump enable/Disable.
7. FXPCG-2 FX-80 Readable Points
- a. DDC system graphic.
 - b. Onicon flow reading (GPM)
 - c. Chilled Water Supply Temperature Building (F)
 - d. Chilled Water Return Temperature Building (F)
 - e. Command signal from AHU 1 through 3 (if monitoring)
8. Outdoor Temperature Sensor (Hx67x3 Series Transmitter temperature/humidity)
FX-80 Readable Points
- a. DDC system graphic.
 - b. Outdoor Temperature (F)
 - c. Outdoor Relative Humidity (%RH)

1.6 Trending

- A. Trend the following points for a 6 month period of time through the FX-80:
- 1. Outdoor Temperature.
 - 2. Outdoor Humidity.
 - 3. Low ambient protection command history.
 - 4. Pump primary/back-up status.

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5. VFD specific command speeds.
6. Chiller operational command.
7. Chiller discharge set point.
8. Command AHU-1 through 3 in the cooling cycle.
9. Switch Board Generator enable.
10. Small Mammal Circulation Pump command.
11. Small Mammal Pump Operational Proof.
12. All chiller Alarms.
13. All VFD Alarms.

END OF SECTION

SECTION 232113
HYDRONIC PIPING

SECTION 232113 - HYDRONIC PIPING

1.1 SUMMARY

- A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
 - 1. Chilled-water piping.
 - 2. Bag Filter Piping

1.2 PERFORMANCE REQUIREMENTS

- A. Minimum Working Pressures and Temperatures:
 - 1. Chilled-Water Heating Piping: 125 psig at 200 deg
 - 2. Bag Filter Piping: 200 deg F

1.3 QUALITY ASSURANCE

- A. Quality Standard: ASME B31.9.

1.4 PRODUCTS

- A. Valves:
 - 1. As noted in "General Duty Valves" Specification Section.
 - 2. Automatic Flow-Control Valves: Brass or ferrous metal body; corrosion-resistant piston and spring assembly; combination assemblies include bronze or brass-alloy ball valve. Manufacturer: Bell and Gossett.
- B. Hydronic Piping Specialties:
 - 1. Strainers: Y-pattern, basket. Manufacturer: Bell and Gossett
 - 2. Flexible Connectors: Stainless-steel bellows with woven-wire jacket.
 - 3. Check Valves: Mueller Swing Type Gravity Operated Check Valve (FLXFL)

1.5 PIPING APPLICATIONS

- A. Piping, aboveground, NPS 2 and smaller, shall be the following:
 - 1. Schedule 40 Black Steel, threaded connection
- B. Piping, aboveground, NPS 2 and larger, shall be the following:

1. Schedule 40 Black Steel, Flanged Connection

1.6 VALVE APPLICATIONS

- A. Shutoff-duty valves are for each installation in branch connection to supply mains, and at supply connection to each piece of equipment.
- B. Calibrated-orifice, balancing valves are for installation in return pipe of each heating coil.
- C. Check valves are for installation in each pump discharge and elsewhere as required to control flow direction.

END OF SECTION 232113

SECTION 232116
HYDRONIC PIPING SPECIALTIES

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. Hydronic specialty valves.
 - 2. Strainers.
 - 3. Connectors.
 - 4. Check Valves

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product:
 - 1. Include construction details and material descriptions for hydronic piping specialties.
 - 2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
 - 3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For hydronic piping specialties to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.6 QUALITY ASSURANCE

- A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

- B. Safety Valves and Pressure Vessels: Shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 HYDRONIC SPECIALTY VALVES

- A. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Hays Fluid Controls; Series CBVF Combination Butterfly/Venturi with Flange or a comparable product by one of the following:
 - a. Flow Design, Inc.
 - b. Griswold Controls.
 - c. Oventrop Corporation.
 - d. Red White Valve Corp.
 - e. Tour & Andersson; available through Victaulic Company.
 - 2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
 - 3. Ball: Combination butterfly valve, brass, or stainless steel.
 - 4. Stem Seals: EPDM O-rings.
 - 5. Disc, NPS 2-1/2 to NPS 8 (DN 65 to DN 200): Aluminum-bronze sand casting, ASTM B148 C95800.
 - 6. Disc, NPS 10 and NPS 12 (DN 250 and DN 300): Nickel plated aluminum-bronze sand casting, ASTM B148 C95800.
 - 7. Seat: PTFE, bonded EPDM.
 - 8. End Connections: Flanged or grooved.
 - 9. Pressure Gage Connections: Integral seals for portable differential pressure meter.
 - 10. Handle Style: Combination infinite/10-position memory stop plate, a one-piece disc/shaft, and a triple shaft bearing.
 - 11. CWP Rating: Minimum 125 psig (860 kPa).

2.2 STRAINERS

- A. Y-Pattern Strainers:
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Hays Fluid Controls or comparable product by one of the following:
 - a. Flow Design, Inc.
 - b. Griswold Controls.
 - c. HCI; Hydronics Components Inc.
 - 2. Body: Brass or ASTM A 126, Class B, with bolted cover and bottom drain connection.

3. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
4. Strainer Screen: Stainless-steel, 20-mesh strainer, or perforated stainless-steel basket.
5. CWP Rating: 125 psig (860 kPa).

B. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: 40 mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig (860 kPa).

C. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: 40 mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: 750 psig (5170 kPa).

2.3 CONNECTORS

A. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch (20-mm) misalignment.
4. CWP Rating: 150 psig (1035 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

B. Spherical, Rubber, Flexible Connectors:

1. Body: Fiber-reinforced rubber body.
2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
3. Performance: Capable of misalignment.
4. CWP Rating: 150 psig (1035 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

2.4 CHECK VALVES: Mueller Swing Type Gravity Operated Check Valve (FXLFL)

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

- A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.
- B. Install check valves at each pump discharge and elsewhere as required to control flow direction.

3.2 HYDRONIC SPECIALTIES INSTALLATION

- A. Install Bag Filter on the remaining floor slab. Install piping to both the hot and chilled water supply and return mains.

END OF SECTION 232116

SECTION 232123
HYDRONIC PUMPS

1.1 SUMMARY

- A. Close-coupled, in-line centrifugal pumps.

1.2 QUALITY ASSURANCE

- A. Quality Standard: UL 778.

1.3 PRODUCTS

- A. Close-Coupled, In-Line Centrifugal Pumps:
 - 1. Casing: Radially split, cast iron.
 - 2. Impeller: Cast bronze.
 - 3. Pump Shaft: Steel, with copper-alloy shaft sleeve.
 - 4. Seal: Mechanical.
 - 5. Pump Bearings: Permanently lubricated ball bearings.

PART 2 - PRODUCTS

2.1 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

- A. Manufacturers:
 - 1. Bell & Gossett; Div. of ITT Industries.
 - 2. Approved Equal.
- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically. Rate pump for 125-psig minimum working pressure and a continuous water temperature of 200 deg F.
- C. Pump Construction:
 - 1. Casing: Radially split, cast iron, with 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 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 gasket. Include water slinger on shaft between motor and seal.

5. Packing Seal: Stuffing box, with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
6. Pump Bearings: Permanently lubricated ball bearings.
7. Permanently lubricated ball bearings are available up through 5 hp. Larger motors have grease-lubricated ball bearings.

D. Motor: NEMA 254

END OF SECTION 232123

SECTION 233300
AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
1. Duct-mounted access doors.

1.2 SUBMITTALS

- A. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.
1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction.
- B. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Comply with 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: Comply with ASTM A 653/A 653M.
1. Galvanized Coating Designation: G90 (Z275).
 2. Exposed-Surface Finish: Mill phosphatized.
- C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- D. 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.

2.2 DUCT-MOUNTED ACCESS DOORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following”
1. American Warming and Ventilating; a division of Mestek, Inc.
 2. Cesco Products; a division of Mestek, Inc.
 3. Ductmate Industries, Inc.
- B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."
1. Door:
 - a. Double wall, rectangular.
 - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. Vision panel.
 - d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
 - e. Fabricate doors airtight and suitable for duct pressure class.
 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 3. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
 - c. Access Doors up to 24 by 48 Inches: three hinges and two compression latches with outside and inside handles.
 - d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

2.3 DUCT ACCESS PANEL ASSEMBLIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Ductmate Industries, Inc.
 2. Flame Gard, Inc.
 3. 3M.
- B. Panel and Frame: Minimum thickness.0428-inch stainless steel.
- C. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.
- D. Minimum Pressure Rating: 10-inch wg, positive or negative.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct accessories according to applicable details in 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. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. At each change in direction and at maximum 50-foot spacing.
 - 2. Upstream [and downstream] from turning vanes.
- D. Install access doors with swing against duct static pressure.
- E. Access Door Sizes:
 - 1. Head and Hand Access: 18 by 10 inches.
 - 2. Head and Shoulders Access: 21 by 14 inches
- F. Label access doors according to Division 23 Section "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

3.2 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Operate dampers to verify full range of movement.
 - 2. Inspect locations of access doors and verify that purpose of access door can be performed.

END OF SECTION 233300

SECTION 236426
AIR-COOLED, ROTARY-SCREW WATER CHILLERS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes design, performance criteria, refrigerants, controls, and installation requirements for air-cooled rotary screw packaged chillers.

1.02 REFERENCES

- A. AHRI 550/590 - Standard for Water Chilling Packages using the Vapor Compression Cycle
- B. AHRI 370 - Sound Rating of Large Outdoor Refrigerating and Air-Conditioning Equipment
- C. ASHRAE 15 - Safety Code for Mechanical Refrigeration
- D. ASHRAE 90.1 - Energy Efficient Design of New Buildings
- E. UL 1995 - Central Cooling Air Conditioners
- F. ASTM B117 - Standard Method of Salt Spray (Fog) Testing
- G. ASTM A123 - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- H. ASTM A525 - Zinc (Hot-Dip Galvanized) Coatings on Sheet Steel Products
- I. ASTM D1654 - Evaluation of Painted or Coated Specimens, Subjected to Corrosive Environments
- J. ANSI/AFBMA 9-1978 - Load Ratings and Fatigue Life for Ball Bearings.
- K. ISO 9001
- L. California Administrative Code - Title 24

1.03 SUBMITTALS

- A. Submit dimensional plan and elevation view drawings, weights and loadings, required clearances, location and size of all field connections, electrical requirements and wiring diagrams.
- B. Submit product data indicating rated capacities, accessories and any special data.
- C. Submit manufacturer's installation instructions.
- D. Submit AHRI certificate in accordance with the latest editions of ANSI/AHRI Standards 550/590(I-P) with addendum 3 for Performance Rating of Water-Chilling and Heat Pump Water-Chilling Packages using Vapor Compression Cycle.
- E. Submit part load data per the following:
 - 1. Ambient temp of 95F; Load of 100% / 90% / 80% / 70% / 60% / 50% / 40% / 30% / 20%
 - 2. Ambient temp of 85F; Load of 100% / 90% / 80% / 70% / 60% / 50% / 40% / 30% / 20%
 - 3. Ambient temp of 75F; Load of 100% / 90% / 80% / 70% / 60% / 50% / 40% / 30% / 20%
 - 4. Ambient temp of 65F; Load of 100% / 90% / 80% / 70% / 60% / 50% / 40% / 30% / 20%

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5. Ambient temp of 55F; Load of 100% / 90% / 80% / 70% / 60% / 50% / 40% / 30% / 20%
6. All (45) data points to include Capacity (in Tons or MBH), LWT (F), EWT (F), Flow (gpm), Water Pressure Drop (ft H₂O), Ambient Temp (F), Power (KW), and EER (BTU/W-h)

1.04 REGULATORY REQUIREMENTS

- A. Comply with codes and standards specified.
- B. Chiller must be built in an ISO 9001 classified facility.

1.05 VERIFICATION OF CAPACITY AND EFFICIENCY

- A. All proposals for chiller performance must include an AHRI approved selection method. Verification of date and version of computer program selection or catalog is available through AHRI.

1.06 DELIVERY, HANDLING AND STORAGE

- A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting chillers.
- B. Chiller shall be capable of withstanding -40°F (-40 °C) to 158 F (70 °C) storage temperatures for an indefinite period of time.

1.07 WARRANTY

- A. Provide a full unit warranty for two years from start-up or 30 months from shipment, whichever occurs first.
- B. Provide a 3rd through 5th year compressor warranty (parts only)

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Trane model RTAC
- B. Approved equals, must have screw compressor and meet the specification including all scheduled performance.

2.02 CHILLER DESCRIPTION

- A. The contractor shall furnish and install air-cooled water chiller with screw compressors as shown as scheduled on the contract documents. The chillers shall be installed in accordance with this specification and perform at the specified conditions as scheduled.

2.03 CHILLER OPERATION

- A. Chiller shall be capable of starting and running at outdoor ambient temperatures from 0°F to 115 °F.
- B. Chiller shall be capable of operating with a leaving solution temperature range 40 to 65°F without glycol.
- C. Chiller shall be capable of starting up with 95°F (35 °C) entering fluid temperature to the evaporator. Maximum water temperature that can be circulated with the Chiller not operating is 108°F (42 °C)
- D. Chiller shall provide evaporator freeze protection and low limit control to avoid low evaporator refrigerant temperature trip-outs during critical periods of chiller operation. Whenever this control is in effect, the controller shall indicate that the chiller is in adaptive mode. If the condition exists for more than 30 seconds, a limit warning alarm relay shall energize.

2.04 COMPRESSORS

- A. Construct semi-hermetic helical rotary screw compressors with heat treated forged steel or ductile iron shafts, and sealing surface immersed in oil. Rotors shall be of high grade steel or iron alloy.
 - 1. Scroll compressors are not acceptable.
- B. Statically and dynamically balance rotating parts.
- C. Provide oil lubrication system with oil charging valve and oil filter to ensure adequate lubrication during starting, stopping, and normal operation.
- D. Provide compressor with automatic capacity reduction equipment consisting of capacity control slide valve. Compressor must start unloaded for soft start on motors.
- E. Provide constant speed 3600 rpm for 60Hz (or 3000 rpm for 50Hz) compressor motor, suction gas cooled with robust construction and system design protection, designed for across-the-line or wye-delta starting. Furnish with starter.
- F. Provide compressor heater to evaporate refrigerant returning to compressor during shut down. Energize heater when compressor is not operating.

2.05 EVAPORATOR

- A. The evaporator shall be designed, tested, and stamped in accordance with ASME code for a refrigerant side working pressure of 200 psig. Waterside working pressure shall be 150 psig.
- B. Insulate the evaporator with a minimum of 0.75 inch (K=0.28) UV rated insulation. If the insulation is field installed, the additional money to cover material and installation costs in the field should be included in the bid.
- C. Evaporator heaters shall be factory installed and shall protect chiller down to -20°F. Contractor shall wire separate power to energize heat tape and protect evaporator while chiller is disconnected from the main power.
- D. Provide shell and tube type evaporator, seamless or welded steel construction with cast iron or fabricated steel heads, seamless internally and externally finned copper tubes, roller expanded into tube sheets.
- E. Provide ability to remove evaporator tubes from either end of the heat exchanger.
- F. Evaporator shall have cleanable tubes
- G. Provide water drain connection, vent and fittings. Factory installed leaving water temperature control and low temperature cutout sensors.
- H. Water connections shall be grooved pipe.

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- I. Proof of flow shall be provided by the equipment manufacturer, mechanically installed and electrically wired, at the factory of origin.
- J. Provide a raised face flange kit that converts the grooved pipe evaporator water connections to flange connectors.

2.06 FANS

- A. Fans shall be dynamically balanced and direct driven.
- B. All condenser fan TEAO motors have permanently lubricated ball bearings and external overload protection.
- C. Provide complete fan assembly combining ultra quiet nine blade fans and TEAO fan motors to provide sound reductions with no performance degradation to the unit. The fan blades are heavy-duty molded plastic with wavy edges to reduce air-flow turbulence.

2.07 CONDENSER

- A. The condenser coils shall consist of copper tubes mechanically bonded into plate-type aluminum fins. A subcooling coil shall be an integral part of the main condenser coil. Air test under water to 506 psig.

2.08 ENCLOSURES/CHILLER CONSTRUCTION

- A. Units shall be constructed of a steel frame with galvanized steel panels and access doors.
- B. Chiller panels, base rails and control panels shall be finished with a baked on powder paint. Control panel doors shall have door stays.
- C. Mount starters and Terminal Blocks in a UL 1995 rated weatherproof panel provided with full opening access doors. If a circuit breaker is chosen, it should be a lockable, through-the-door type with an operating handle and clearly visible from outside of chiller indicating if power is on or off.
- D. The coating or paint system shall withstand 500 hours in a salt-spray fog test in accordance with ASTM B117.

2.09 CHILLER MOUNTED STARTER

- A. The starter shall be reduced inrush, wye-delta starter factory-mounted and fully pre-wired to the compressor motor(s) and control panel.
- B. A control power transformer shall be factory-installed and factory-wired to provide unit control power.
- C. Unit shall have a single point power connection.
- D. A molded case standard interrupting capacity circuit breaker shall be factory pre-wired with terminal block power connections and equipped with a lockable external operator handle, making it available to disconnect the chiller from main power.
- E. Provide a High short circuit current rating (SCCR) of 65kA with selection of high fault protection device.
- F. Provide a customer wired 15 amp, 115-volt GFCI convenience outlet that shall be factory mounted on the exterior of the control panel.

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2.10 REFRIGERANT CIRCUIT

- A. All chillers shall have 2 refrigeration circuits, each with one or two (manifolded) compressors on each circuit.
- B. Provide for refrigerant circuit:
 - 1. Liquid line shutoff valve
 - 2. Discharge service valve
 - 3. Suction line service valve
 - 4. Filter with replaceable core
 - 5. Liquid line sight glass.
 - 6. Electronic expansion valve sized for maximum operating pressure
 - 7. Charging valve
- C. Provide a full operating charge of R-410A and oil.

2.11 CONTROLS

- A. Factory-mounted to the control panel door, the operator interface has an LCD touch-screen display.
- B. Display shall consist of a menu driven interface with easy touch screen navigation to organized sub-system reports for compressor, evaporator, and motor information as well as associated diagnostics.
- C. The chiller control panel shall provide password protection of all set-points
- D. Chilled water temperature control shall be microprocessor-based, proportional and integral controller to show water and refrigerant temperature, refrigerant pressure, and diagnostics. This microprocessor-based controller is to be supplied with each chiller by the chiller manufacturer.
- E. The front of the chiller control panel shall display the following in clear language, without the use of codes, look-up tables, or gauges:
 - 1. Run time.
 - 2. Number of starts.
 - 3. Current chiller operating mode.
 - 4. Chilled water set point and set point source.
 - 5. Electrical current limit set point and set point source.
 - 6. Entering and leaving evaporator water temperatures.
 - 7. Saturated evaporator and condenser refrigerant temperatures.
 - 8. Evaporator and condenser refrigerant pressure.
 - 9. Differential oil pressure.
 - 10. Phase reversal/unbalance/single phasing and over/under voltage protection.
 - 11. Low chilled water temperature protection.
 - 12. High and low refrigerant pressure protection.
 - 13. Load limit thermostat to limit compressor loading on high return water temperature.

14. Condenser fan sequencing to automatically cycle fans in response to load, expansion valve pressure, condenser pressure, and differential pressure to optimize chiller efficiency.
 15. Display diagnostics.
 16. Compressors: Status (on/off), %RLA, anti-short cycle timer, and automatic compressor lead-lag.
- F. On chiller, mount weatherproof control panel, containing starters, power and control wiring, factory wired with terminal block power connection. Provide primary and secondary fused control power transformer.
- G. The chiller controller shall utilize a microprocessor that will automatically take action to prevent chiller shutdown due to abnormal operating conditions associated with: evaporator refrigerant temperature, high condensing pressure and motor current overload.
- H. Provide the following safety controls with indicating lights or diagnostic readouts.
1. Low chilled water temperature protection.
 2. High refrigerant pressure.
 3. Loss of chilled water flow.
 4. Contact for remote emergency shutdown.
 5. Motor current overload.
 6. Phase reversal/unbalance/single phasing.
 7. Over/under voltage.
 8. Failure of water temperature sensor used by controller.
 9. Compressor status (on or off).
- I. Provide the following operating controls:
1. A variable method to control capacity in order to maintain leaving chilled water temperature based on PI algorithms. Five minute solid state anti-recycle timer to prevent compressor from short cycling. Compressor minimum stop-to-start time limit shall be 2 minutes. If a greater than 5 minute start-to-start, or greater than 2 minute stop-to-start timer is included, hot gas bypass shall be provided to insure accurate chilled water temperature control in light load applications.
 2. Chilled water pump output relay that closes when the chiller is given a signal to start.
 3. Load limit thermostat to limit compressor loading on high return water temperature to prevent nuisance trip outs.
 4. High ambient unloader pressure controller that unloads compressors to keep head pressure under control and help prevent high pressure nuisance trip outs on days when outside ambient is above design.
 5. Compressor current sensing unloader chiller that unloads compressors to help prevent current overload nuisance trip outs.
 6. Low ambient lockout control with adjustable setpoint.
 7. Condenser fan sequencing which adjusts the speed of all fans automatically in response to ambient, condensing pressure and expansion valve pressure differential thereby optimizing chiller efficiency.

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- J. Provide BACNET user interface on the front of the panel. If display is on the inside of the panel, then a control display access door shall be provided to allow access to the display without removal of panels. Provide user interface with a minimum of the following points (MS/TP)
 - 1. Leaving chilled water setpoint adjustment from LCD input
 - 2. Entering and leaving chilled water temperature output
 - 3. Pressure output of condenser
 - 4. Pressure output of evaporator
 - 5. Ambient temperature output
 - 6. Voltage output
 - 7. Current limit setpoint adjustment from LCD input.
- K. The chiller control panel shall provide leaving chilled water temperature reset based upon return water temperature.
- L. Provide Digital Communications to BAS system that shall consist of a BACnet MS/TP interface via a single twisted pair wiring.

2.12 SOUND

- A. Acoustics: Manufacturer must provide both sound power and sound pressure data in decibels. Sound pressure data per AHRI 370 must be provided at full load. In addition, A-weighted sound pressure at 30 feet should be provided at 100% load point.
- B. If manufacturer cannot meet the noise levels, sound attenuation devices and/or barrier walls must be installed to meet this performance level.
- C. Provide an acoustical treatment for compressor and low noise fans.

2.13 ACCESSORIES

- A. Provide Chiller shall with full architectural louvers panels.
- B. 65,000 SCCR rating
- C. Low noise fans and compressor sound wrap
- D. Refrigerant service valves (suction, discharge, and liquid line shut off valves)

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's requirements.
 - 1. Level the chiller using the base rail as a reference. The chiller must be level within 1/4" in over the entire length and width. Use shims as necessary to level the chiller.

3.02 SERVICE AND START-UP

- A. Startup - Provide all labor and materials to perform startup. Startup shall be performed by a factory-trained technician from the original equipment manufacturer (OEM). Technician shall confirm that equipment has been correctly installed and

- passes specification checklist prior to equipment becoming operational and covered under OEM warranty. This shall be done in strict accordance with manufacturer's specifications and requirements. Third-party service agencies are not permitted.
- B. A start-up log shall be furnished by the factory approved start-up technician to document the chiller's start-up date and shall be signed by the owner or his authorized representative prior to commissioning the chillers.
 - C. Chiller manufacturers shall maintain service capabilities no more than X miles from the jobsite.
 - D. Provide local service agent with direct access to factory support on equipment.
 - E. The service provider shall employ a minimum of (30) full time, competent HVAC and automation system servicepersons on staff, whose office in which they operate from is within (30) miles of the job site and who have been within their employment for a minimum of (20) years.
 - F. During the first 12 months of operation, a factory-trained technician from the original equipment manufacturer (OEM) shall perform quarterly on-site operating inspections to confirm the chiller's operational performance. The manufacturer shall provide the owner with a report describing the condition of the equipment, current operating log, any issues found needing to be addressed, and recommended corrective actions.

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SECTION 26 0500
COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
1. Sleeves for raceways and cables.
 2. Sleeve seals.
 3. Grout.
 4. Common electrical installation requirements.

1.2 SUBMITTALS

- A. Product Data: For sleeve seals.

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 (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).
- D. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

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- 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.

2.2 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 ELECTRICAL 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 electrical 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 ELECTRICAL PENETRATIONS

- A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways 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.

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- 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 (50 mm) above finished floor level.
 - G. Size pipe sleeves to provide 1/4-inch (6.4-mm) 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 (25-mm) 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 (25-mm) 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 electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

END OF SECTION

SECTION 26 0519
LOW VOLTAGE POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Building wires and cables rated 600 V and less.
 - 2. Connectors, splices, and terminations rated 600 V and less.
 - 3. Sleeves and sleeve seals for cables.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control test reports.

1.3 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. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- A. Copper Conductors: Comply with NEMA WC 70.
- B. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN, XHHW, USE and SO.
- C. Multiconductor Cable: Comply with NEMA WC 70 for metal-clad cable, Type MC mineral-insulated, metal-sheathed cable, Type MI, nonmetallic-sheathed cable, Type NM, Type SO and Type USE with ground wire.

2.2 CONNECTORS AND SPLICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AFC Cable Systems, Inc.
 2. Hubbell Power Systems, Inc.
 3. O-Z/Gedney; EGS Electrical Group LLC.
 4. 3M; Electrical Products Division.
 5. Tyco Electronics Corp.
- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SLEEVES FOR 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. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

2.4 SLEEVE SEALS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Advance Products & Systems, Inc.
 2. Calpico, Inc.
 3. Metraflex Co.
 4. Pipeline Seal and Insulator, Inc.
- B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
1. 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.
 2. Pressure Plates: Carbon steel. Include two for each sealing element.

3. 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.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type THHN-THWN, single conductors in raceway
- B. Exposed Feeders: Type THHN-THWN, single conductors in raceway
- C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THWN, single conductors in raceway, Metal-clad cable, Type MC.
- D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway
- E. Exposed Branch Circuits, Including in Crawlspace: Type THHN-THWN, single conductors in raceway
- F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway, Metal-clad cable, Type MC
- G. Coordinate first paragraph below with Division 26 Section "Underground Ducts and Raceways for Electrical Systems."
- H. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway
- I. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- J. Class 1 Control Circuits: Type THHN-THWN, in raceway.
- K. Class 2 Control Circuits: Type THHN-THWN, in raceway

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
- B. 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.
- C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- E. Support cables according to Division 26 Sections "Hangers and Supports for Electrical Systems."
- F. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."
- G. 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.
- H. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
 - 1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.
- I. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches (300 mm) of slack.

3.4 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."
- 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. 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.
- D. Cut sleeves to length for mounting flush with both wall surfaces.
- E. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.

- F. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
- G. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
- H. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Joint Sealants."
- I. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 07 Section "Penetration Firestopping."
- J. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.
- K. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- L. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.5 SLEEVE-SEAL INSTALLATION

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

3.6 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping."

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors 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.
3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.
 - a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
 - b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

C. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

D. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION

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LOW VOLTAGE ELECTRICAL
POWER CONDUCTORS AND CABLES

SECTION 26 0526
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes methods and materials for grounding systems and equipment.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control test reports.

1.3 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. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. Tinned Conductors: ASTM B 33.
 - 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

2.2 CONNECTORS

- A. Listed and labeled by a nationally recognized testing laboratory 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, bolted pressure-type, with at least two bolts.
 1. Pipe Connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad; 3/4 inch by 10 feet (19 mm by 3 m) in diameter.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum. Bury at least 24 inches (600 mm) below grade.
- C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- D. 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.

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GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

3.2 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
1. Feeders and branch circuits.
 2. Lighting circuits.
 3. Receptacle circuits.
 4. Single-phase motor and appliance branch circuits.
 5. Three-phase motor and appliance branch circuits.
 6. Flexible raceway runs.
 7. Armored and metal-clad cable runs.
 8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
 9. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.
 10. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.
- B. 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.
- C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- D. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.
- E. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.
- F. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.

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GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-12-inch (6-by-50-by-300-mm) grounding bus.
 2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
- G. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.3 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.
- B. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade, unless otherwise indicated.
1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.
 2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- C. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Division 26 Section "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches (300 mm) deep, with cover.
1. Test Wells: Install at least one test well for each service, unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- D. 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 so vibration is not transmitted to rigidly mounted equipment.
 3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.
- E. Grounding and Bonding for Piping:

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26 0526-4

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- F. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections and prepare test reports:
1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells.
 - a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
- B. Report measured ground resistances that exceed the following values:
1. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.
 2. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.
 3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
 4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).
- C. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION

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26 0526-5
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

SECTION 26 0259
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.

1.2 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.3 SUBMITTALS

- A. Product Data: For steel slotted support systems.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
 - 1. Trapeze hangers. Include Product Data for components.
 - 2. Steel slotted channel systems. Include Product Data for components.
 - 3. Equipment supports.
- C. Welding certificates.

1.4 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.
 - c. ERICO International Corporation.
 - d. GS Metals Corp.
 - e. Thomas & Betts Corporation.
 - f. Unistrut; Tyco International, Ltd.
 - g. Wesanco, Inc.
 - 3. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - 4. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 - 5. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - 6. Channel Dimensions: Selected for applicable load criteria.
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- 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 malleable iron.

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- 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. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Hilti Inc.
 - 2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 3) MKT Fastening, LLC.
 - 4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.

 - 2. 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 in which used.
 - a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2) Empire Tool and Manufacturing Co., Inc.
 - 3) Hilti Inc.
 - 4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 5) MKT Fastening, LLC.

 - 3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
 - 4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
 - 5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
 - 6. Toggle Bolts: All-steel springhead type.
 - 7. Hanger Rods: Threaded steel.

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26 0529-3

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

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.
- B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

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 except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted 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.
- D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.
- C. 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 (90 kg).
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

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26 0529-4

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

1. To Wood: Fasten with lag screws or through bolts.
 2. To New Concrete: Bolt to concrete inserts.
 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 4. To Existing Concrete: Expansion anchor fasteners.
 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
 6. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69
 7. To Light Steel: Sheet metal screws.
 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Division 05 Section "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 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section Cast-in-Place Concrete.
- C. Anchor equipment to concrete base.
 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 2. Install anchor bolts to elevations required for proper attachment to supported equipment.

3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).
- B. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 26 0533
RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.
- B. See Division 26 Section "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks and manholes, and underground handholes, boxes, and utility construction.

1.2 SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, details, and attachments to other work.

1.3 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. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

- A. Rigid Steel Conduit: ANSI C80.1.
- B. IMC: ANSI C80.6.
- C. EMT: ANSI C80.3.
- D. FMC: Zinc-coated steel.
- E. LFMC: Flexible steel conduit with PVC jacket.

- F. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
 - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
 - 2. Fittings for EMT: set-screw or compression type.

2.2 NONMETALLIC CONDUIT AND TUBING

- A. ENT: NEMA TC 13.
- B. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.
- C. LFNC: UL 1660.
- D. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.
- E. Fittings for LFNC: UL 514B.

2.3 METAL WIREWAYS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper B-Line, Inc.
 - 2. Hoffman.
 - 3. Square D; Schneider Electric.
- C. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, unless otherwise indicated.
- D. Fittings and Accessories: Include 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.
- E. Wireway Covers: Screw-cover type
- F. Finish: Manufacturer's standard enamel finish.

2.4 NONMETALLIC WIREWAYS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Hoffman.
 - 2. Lamson & Sessions; Carlon Electrical Products.
- C. Description: PVC plastic, extruded and fabricated to size and shape indicated, with snap-on cover and mechanically coupled connections with plastic fasteners.
- D. Fittings and Accessories: Include 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.

2.5 SURFACE RACEWAYS

- A. Surface Metal Raceways: Galvanized steel with snap-on covers. Manufacturer's standard enamel finish in color selected by Architect.
- B. See Editing Instruction No. 1 in the Evaluations for cautions about naming manufacturers and products. Retain one of two subparagraphs and list of manufacturers below. See Division 01 Section "Product Requirements."
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Thomas & Betts Corporation.
 - b. Walker Systems, Inc.; Wiremold Company (The).
 - c. Wiremold Company (The); Electrical Sales Division.
- C. Surface Nonmetallic Raceways: Two-piece construction, manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard colors.
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Butler Manufacturing Company; Walker Division.
- b. Enduro Systems, Inc.; Composite Products Division.
- c. Hubbell Incorporated; Wiring Device-Kellems Division.
- d. Lamson & Sessions; Carlon Electrical Products.
- e. Panduit Corp.
- f. Walker Systems, Inc.; Wiremold Company (The).
- g. Wiremold Company (The); Electrical Sales Division.

2.6 BOXES, ENCLOSURES, AND CABINETS

- A. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
- B. Cast-Metal Outlet and Device Boxes: NEMA FB 1, aluminum, Type FD, with gasketed cover.
- C. Nonmetallic Outlet and Device Boxes: NEMA OS 2.
- D. Metal Floor Boxes: Cast or sheet metal, fully adjustable, rectangular.
- E. Nonmetallic Floor Boxes: Nonadjustable, round.
- F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- G. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, cast aluminum with gasketed cover.
- H. Hinged-Cover Enclosures: 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. Nonmetallic Enclosures: Plastic
- I. 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. Outdoors: Apply raceway products as specified below, unless otherwise indicated:

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1. Exposed Conduit: Rigid steel conduit or RNC, Type EPC-80-PVC.
2. Concealed Conduit, Aboveground: Rigid steel conduit or Type EPC-40-PVC.
3. Underground Conduit: RNC, Type EPC-40-PVC, direct buried.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFNC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Comply with the following indoor applications, unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: Rigid steel conduit. Includes raceways in the following locations:
 - 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: Rigid steel conduit.
7. Raceways for Optical Fiber or Communications Cable: EMT.
8. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, nonmetallic in damp or wet locations.

C. Minimum Raceway Size: 3/4-inch (21-mm) trade size.

D. 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.

3.2 INSTALLATION

- A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.
- B. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- C. Complete raceway installation before starting conductor installation.
- D. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."

- E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.
- F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
- H. Raceways Embedded in Slabs:
 - 1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
 - 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
 - 3. Change from ENT to RNC, Type EPC-40-PVC, rigid steel conduit, or IMC before rising above the floor.
- I. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.
- J. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire.
- K. Raceways for Optical Fiber and Communications Cable: Install as follows:
 - 1. 3/4-Inch (19-mm) Trade Size and Smaller: Install raceways in maximum lengths of 50 feet (15 m).
 - 2. 1-Inch (25-mm) Trade Size and Larger: Install raceways in maximum lengths of 75 feet (23 m).
 - 3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- L. Install raceway sealing fittings at suitable, approved, and accessible locations 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. Install raceway sealing fittings at the following points:
 - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 2. Where otherwise required by NFPA 70.

- M. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m).
1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
 - c. Indoor Spaces: Connected with the Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
 - d. Attics: 135 deg F (75 deg C) temperature change.
 2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change.
 3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.
- N. Flexible Conduit Connections: Use maximum of 72 inches (1830 mm) of flexible conduit for recessed and semirecessed lighting fixtures, 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.
- O. 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.
- P. Set metal floor boxes level and flush with finished floor surface.
- Q. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

- A. Direct-Buried Conduit:
1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches (150 mm) in nominal diameter.
 2. Install backfill as specified in Division 31 Section "Earth Moving."
 3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction

as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."

4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
 - b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
6. Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried conduits, placing them 24 inches (600 mm) o.c. Align planks along the width and along the centerline of conduit.

3.4 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

END OF SECTION

SECTION 26 0553
IDENTIFICATION FOR ELECTRICAL SYSTEMS

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. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels.
8. Miscellaneous identification products.

1.2 SUBMITTALS

- A. Product Data: For each electrical identification product indicated.

1.3 QUALITY ASSURANCE

- A. Comply with ANSI A13.1.
- 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.

PART 2 - PRODUCTS

2.1 POWER RACEWAY IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.

- B. Colors for Raceways Carrying Circuits at 600 V or Less:
 - 1. Black letters on an orange field.
 - 2. Legend: Indicate voltage.
- C. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- D. Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- E. Snap-Around, Color-Coding Bands for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- F. Write-On Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
 - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - 2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.2 ARMORED AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Colors for Raceways Carrying Circuits at 600 V and Less:
 - 1. Black letters on an orange field.
 - 2. Legend: Indicate voltage.
- C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- D. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches (50 mm) wide; compounded for outdoor use.

2.3 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- C. Write-On Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
 - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - 2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.
- D. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- E. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

2.4 CONDUCTOR IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.
- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- C. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- D. Write-On Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
 - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - 2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.5 FLOOR MARKING TAPE

- A. 2-inch- (50-mm-) wide, 5-mil (0.125-mm) pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

2.6 UNDERGROUND-LINE WARNING TAPE

A. Tape:

1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

B. Color and Printing:

1. Comply with ANSI Z535.1 through ANSI Z535.5.
2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

C. Tag: Type I:

1. Pigmented polyolefin, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
2. Thickness: 4 mils (0.1 mm).
3. Weight: 18.5 lb/1000 sq. ft. (9.0 kg/100 sq. m).
4. 3-Inch (75-mm) Tensile According to ASTM D 882: 30 lbf (133.4 N), and 2500 psi (17.2 MPa).

D. Tag: Type ID:

1. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
2. Overall Thickness: 5 mils (0.125 mm).
3. Foil Core Thickness: 0.35 mil (0.00889 mm).
4. Weight: 28 lb/1000 sq. ft. (13.7 kg/100 sq. m).
5. 3-Inch (75-mm) Tensile According to ASTM D 882: 70 lbf (311.3 N), and 4600 psi (31.7 MPa).

2.7 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

- C. Baked-Enamel Warning Signs:
 - 1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
 - 2. 1/4-inch (6.4-mm) grommets in corners for mounting.
 - 3. Nominal size, 7 by 10 inches (180 by 250 mm).
- D. Metal-Backed, Butyrate Warning Signs:
 - 1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application.
 - 2. 1/4-inch (6.4-mm) grommets in corners for mounting.
 - 3. Nominal size, 10 by 14 inches (250 by 360 mm).
- E. Warning label and sign 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 (208V-3Ph equipment): "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."
 - 3. Workspace Clearance Warning (480V-3Ph equipment): "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 48 INCHES."

2.8 INSTRUCTION SIGNS

- A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. inches (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes.
 - 1. Engraved legend with black letters on white face.
 - 2. Punched or drilled for mechanical fasteners.
 - 3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.
- B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm).
- C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.

2.9 EQUIPMENT IDENTIFICATION LABELS

- A. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.
- B. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).
- C. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch (25 mm).

2.10 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in Division 09 painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).
- B. 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. Location: 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. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- D. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
- E. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.
- F. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches (150 to 200 mm) below

finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 16 inches (400 mm) overall.

- G. Painted Identification: Comply with requirements in Division 09 painting Sections for surface preparation and paint application.

3.2 IDENTIFICATION SCHEDULE

- A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30A, and 120V to ground: Install labels at 30-foot (10-m) maximum intervals.
- B. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:
 - 1. Emergency Power.
 - 2. Power.
 - 3. UPS.
- C. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.
 - 1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder and branch-circuit conductors.
 - a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit.
 - b. Colors for 208/120-V Circuits:
 - 1) Phase A: Black.
 - 2) Phase B: Red.
 - 3) Phase C: Blue.
 - c. Colors for 480/277-V Circuits:
 - 1) Phase A: Brown.
 - 2) Phase B: Orange.
 - 3) Phase C: Yellow.
 - d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) 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.

- D. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.
- E. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.
- F. 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 the Operation and Maintenance Manual.
- G. 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 both direct-buried cables and cables in raceway.
- H. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- I. 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.
- 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. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer.

- L. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
1. Labeling Instructions:
 - a. Indoor Equipment: Engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.
 - b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
 - c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
 - d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

END OF SECTION

SECTION 262413
SWITCHBOARDS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Distribution Switchboard - Modifications to existing switchboard

1.02 REFERENCES

The switchboard(s) and overcurrent protection devices referenced herein are designed and manufactured according to the following appropriate specifications.

- A. ANSI/NFPA 70 - National Electrical Code (NEC)
- B. ANSI/IEEE C12.16 - Solid State Electricity Metering.
- C. ANSI C57.13 - Instrument Transformers.
- D. NEMA AB 1 - Molded Case Circuit Breakers and Molded Case Switches.
- E. NEMA PB 2 - Deadfront Distribution Switchboards, File E8681
- G. NEMA PB 2.1 - Proper Handling, Installation, Operation and Maintenance of Deadfront Switchboards Rated 600 Volts or Less.
- I. UL 50 - Cabinets and Boxes.
- J. UL 98 - Enclosed and Dead Front Switches.
- K. UL 489 - Molded Case Circuit Breakers.
- L. UL 891 - Dead-Front Switchboards.
- N. Federal Specification W-C-375B/Gen - Circuit Breakers, Molded Case, Branch Circuit And Service.

1.03 SUBMITTALS

- A. Shop Drawings shall indicate front and side enclosure elevations with overall dimensions shown; conduit entrance locations and requirements; nameplate legends; one-line diagrams; equipment schedule; and switchboard instrument details.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect, and handle products in conformance with manufacturer's recommended practices as outlined in applicable Installation and Maintenance Manuals.

- B. Each switchboard section shall be delivered in individual shipping splits for ease of handling. They shall be individually wrapped for protection and mounted on shipping skids.
- C. Inspect and report concealed damage to carrier within their required time period.
- D. Store in a clean, dry space. Maintain factory protection and/or provide an additional heavy canvas or heavy plastic cover to protect structure from dirt, water, construction debris, and traffic. Where applicable, provide adequate heating within enclosures to prevent condensation.
- E. Handle in accordance with NEMA PB 2.1 and manufacturer's written instructions. Lift only by lifting means provided for this express purpose. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.

1.06 ENVIRONMENTAL REQUIREMENTS

- A. Conform to NEMA PB 2 service conditions during and after installation of switchboards.

1.07 MAINTENANCE MATERIALS

- A. Provide one (1) set of installation and maintenance instructions with each switchboard. Instructions are to be easily identified and affixed within the incoming or main section of the line-up.

1.08 WARRANTY

- A. Manufacturer shall warrant equipment to be free from defects in materials and workmanship for the lesser of one (1) year from date of installation or eighteen (18) months from date of purchase.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. All new equipment shall match existing manufacturer - Eaton.

2.02 SWITCHBOARD - GENERAL

- A. Short Circuit Current Rating: All new equipment shall match existing, but be rated with not less than circuit current rating of 42,000 rms symmetrical amperes at 208 VAC.
- D. Enclosure: NEMA 1 Type - General Purpose.
 - 1. New Sections shall be aligned front and rear.

2. Removable steel base channels (1.5 inch floor sills) shall be bolted to the frame to rigidly support the entire shipping section for moving on rollers and floor mounting.
 3. The switchboard enclosure shall be painted on all exterior surfaces. The paint finish shall be a medium gray, ANSI #49, applied by the electro-deposition process over an iron phosphate pre-treatment.
 4. All front covers shall be screw removable with a single tool and all doors shall be hinged with removable hinge pins
 5. Top and bottom conduit areas shall be clearly indicated on shop drawings.
- E. Nameplates: Provide 1 inch high x 3 inches engraved laminated (Gravoply) nameplates for each device. Furnish black letters on a white background for all voltages.
- F. Bus Composition: All bus bars shall be silver-plated copper. Main horizontal bus bars shall be mounted with all three phases arranged in the same vertical plane. Bus sizing shall be based on ANSI standard temperature rise criteria of 65 degrees C over a 40 degrees C ambient (outside the enclosure).
1. Provide a full capacity neutral bus where a neutral bus is indicated on the drawings.
 2. A copper ground bus shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchgear. The ground bus short-time withstand rating shall meet that of the largest circuit breaker within the assembly. The ground bus plating shall match main bus plating.
 3. All hardware used on conductors shall be high-tensile strength and zinc-plated. All bus joints shall be provided with Belleville-type washers.
 4. The primary means of insulation and isolation of main and vertical bus shall be by air gap. Minimal use of insulating material in addition to air gap shall be provided.
- G. Ground Bus: Sized per NFPA70 and UL 891 Tables 25.1 and 25.2 and shall extend the entire length of the switchboard.
- H. Switchboard shall be close coupled to the dry type substation transformer with flexible bus. Cable connections will not be acceptable.

2.03 SWITCHBOARD - INCOMING MAIN SECTION DEVICES

- A. MAIN CIRCUIT BREAKER - POWER CIRCUIT BREAKER-EATON MAGNUM DS
1. Power circuit breaker shall be constructed and tested in accordance with ANSI C37.13, C37.16, C37.17, C37.50, UL 1066 and NEMA SG-3 standards. The circuit breakers shall carry a UL label.

2. Power circuit breaker shall be low-voltage power circuit breakers, Eaton type Magnum DS or approved equal. Circuit breakers shall be UL listed for application in their intended enclosures for 100% of their continuous ampere rating.
3. Breakers shall be manually operated (MO).
4. Circuit breakers shall have a minimum symmetrical interrupting capacity to match existing. To ensure a selective system, all circuit breakers shall have 30-cycle short-time withstand ratings equal to their symmetrical interrupting ratings through 85,000 amperes, regardless of whether equipped with instantaneous trip protection or not.
5. The primary contacts shall have an easily accessible wear indicator to indicate contact erosion.
6. The power circuit breaker shall have three windows in the front cover to clearly indicate any electrical accessories that are mounted in the breaker. The accessory shall have a label that will indicate its function and voltage. The accessories shall be plug and lock type and UL listed for easy field installation. They shall be modular in design and shall be common to all frame sizes and ratings.
7. The breaker control interface shall have color-coded visual indicators to indicate contact open or closed positions as well as mechanism charged and discharged positions. Manual control pushbuttons on the breaker face shall be provided for opening and closing the breaker. The power circuit breaker shall have a "Positive On" feature. The breaker flag will read "Closed" if the contacts are welded and the breaker is attempted to be tripped or opened.
 - a. The breaker shall include pad-lockable pushbutton covers.
8. The current sensors shall have a back-cover window that will permit viewing the sensor rating on the back of the breaker. A rating plug will offer indication of the rating on the front of the trip unit.
9. Power circuit breaker shall offer sixty (60) front mounted dedicated secondary wiring points. Each wiring point shall have finger safe contacts, which will accommodate #10 AWG maximum field connections with ring tongue or spade terminals or bare wire.
10. Microprocessor-based Trip Units
 1. Each power circuit breaker shall be equipped with a true RMS sensing, solid-state tripping system consisting of three current sensors, microprocessor-based trip device and flux-transfer shunt trip. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection functions. Interchangeable current sensors with their associated rating plug shall establish the continuous trip rating of each circuit breaker.
 2. Trip units shall have an information system that provides LEDs to indicate mode of trip following an automatic trip operation. The indication of the mode of trip shall be retained after an automatic trip. A reset button shall be provided to turn off the LED indication after an automatic trip.
 3. Trip units shall be provided with a display panel, including a representation of the time/current curve, that will indicate the protection functions.

4. Trip units shall be continuously self-checking and provide a visual indication that the internal circuitry is being monitored and is fully operational.
5. Trip units shall be provided with a making-current release circuit. The circuit shall be armed for approximately two cycles after breaker closing and shall operate for all peak fault levels above 25 times the ampere value of the rating plug.
6. Trip units shall have selectable thermal memory for enhanced circuit protection.
7. Trip units shall include the following individually adjustable time/current curve shaping solid-state elements:
 - a. Programmable long-time setting
 - b. Programmable long-time delay with selectable I^2t [and I^4t curve shaping – DT-1150+ only]
 - c. Programmable short-time setting
 - d. Programmable short-time delay with selectable flat or I^2t curve shaping
 - e. Programmable instantaneous setting including OFF position
8. Trip units shall provide zone selective interlocking (ZSI) for the short-time delay and ground fault delay trip functions for improved system protection and arc energy reduction. For faults within the protected zone, the zone interlocking system shall override programmed time delays to allow the upstream breaker to trip with minimal time delay.
 - a. Factory shall wire for zone interlocking for the circuit breakers within the switchgear.
9. Cause-of-trip LED indications shall include battery backup to indicate mode of trip following an automatic trip operation. A test pushbutton shall energize an LED to indicate the battery status.
10. Trip units shall have provisions for a single test kit to test each of the trip functions.
11. Advanced Trip Unit Features
 - Digitrip 1150+
 - a. The display for the trip units shall be a 24-character LED display.
 - b. Trip units shall be equipped to permit communication via a network twisted pair to the LAN system provided in the equipment for remote monitoring and control. All monitored parameters and statuses shall be transmitted.
 - c. Trip units shall include power, energy, and power quality metering. Metering accuracy of the complete system, including current sensors, auxiliary CTs, and the trip unit, shall be +/- 1% of full scale for current and voltage values. Metering accuracy of the complete system shall be +/- 2% of full scale for power and energy values.
 - d. The unit shall be capable of monitoring the following data:
 1. Individual phase, neutral, and ground current
 2. Voltage
 3. Minimum and maximum current values

4. Watts, Vars, VA, Watthours, Varhours, VA hours, Peak demand, Present demand, and energy consumption.
5. Crest Factor, Power Factor, Total Harmonic Distortion, and harmonic values of all phases through the 31st harmonic.
- e. The trip unit shall capture waveforms after a trip event or at the command of the user.
- f. The trip unit shall include a voltage transformer module, suitable for operation up to 600V, 50/60 Hz. The primary of the power relay module shall be connected internally to the line side of the circuit breaker through a dielectric test disconnect plug.
- g. An adjustable high load alarm shall be provided, adjustable from 50 to 100% of the long delay pickup setting.
- h. The trip unit shall contain an integral test pushbutton. A keypad shall be provided to enable the user to select the values of test currents within a range of available settings. The protection functions shall not be affected during test operations. The breaker may be tested in the TRIP or NO TRIP test mode.
- i. The trip unit shall include a power/relay module, which shall supply control power to the readout display. Following an automatic trip operation of the circuit breaker, the trip unit shall maintain the cause of trip history and the mode of trip LED indication as long as its internal power supply is available. An internal relay shall be programmable to provide contacts for remote ground alarm indication.
- j. Programming may be done via a keypad at the faceplate of the unit or via the communication network.
- k. The trip unit shall offer a three-event trip log that will store the trip data, and shall time and date stamp the event.
- l. The trip unit shall have the following advanced protective features integral to the trip unit:
 1. Adjustable undervoltage release
 2. Adjustable overvoltage release
 3. Reverse power and fault current
 4. Reverse sequence voltage alarm
 5. Underfrequency
 6. Overfrequency
 7. Voltage phase unbalance and phase loss during current detection
 8. Where the above protection(s) are not available as an integral part of the trip unit, provide separate relay(s) factory mounted and wired to a breaker shunt trip.

B. MAIN CIRCUIT BREAKER-INSULATED CASE CIRCUIT BREAKERS -EATON MAGNUM SB

1. Protective device shall be switchboard class insulated case low-voltage power circuit breakers, Eaton type Magnum SB or approved equal.

2. Circuit breaker shall be UL listed for application in their intended enclosures for 100% of their continuous ampere rating.
3. Breakers shall be manually operated (MO)
4. Circuit breakers shall have a minimum symmetrical interrupting capacity to match existing. To ensure a selective system, all circuit breakers shall have 30-cycle short-time withstand ratings equal to 18 times their frame ratings. Insulated case circuit breakers shall be equipped with a fixed internal instantaneous override set at that level.
5. The primary contacts shall have an easily accessible wear indicator to indicate contact erosion.
6. The insulated case circuit breaker shall have three windows in the front cover to clearly indicate any electrical accessories that are mounted in the breaker. The accessory shall have a label that will indicate its function and voltage. The accessories shall be plug and lock type and UL listed for easy field installation. They shall be modular in design and shall be common to all frame sizes and ratings.
7. The breaker control interface shall have color-coded visual indicators to indicate contact open or closed positions as well as mechanism charged and discharged positions. Manual control pushbuttons on the breaker face shall be provided for opening and closing the breaker. The insulated case circuit breaker shall have a "Positive On" feature. The breaker flag will read "Closed" if the contacts are welded and the breaker is attempted to be tripped or opened.
 - a. The breaker shall include padlockable pushbutton covers.
8. The current sensors shall have a back-cover window that will permit viewing the sensor rating on the back of the breaker. A rating plug will offer indication of the rating on the front of the trip unit.
9. Each insulated case circuit breaker shall offer sixty (60) front mounted dedicated secondary wiring points. Each wiring point shall have finger safe contacts, which will accommodate #10 AWG maximum field connections with ring tongue or spade terminals or bare wire.
10. Microprocessor-based Trip Units
 1. Each power circuit breaker shall be equipped with a true RMS sensing, solid-state tripping system consisting of three current sensors, microprocessor-based trip device and flux-transfer shunt trip. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection functions. Interchangeable current sensors with their associated rating plug shall establish the continuous trip rating of each circuit breaker.
 2. Trip units shall have an information system that provides LEDs to indicate mode of trip following an automatic trip operation. The indication of the mode of trip shall be retained after an automatic trip. A reset button shall be provided to turn off the LED indication after an automatic trip.
 3. Trip units shall be provided with a display panel, including a representation of the time/current curve, that will indicate the protection functions.

4. Trip units shall be continuously self-checking and provide a visual indication that the internal circuitry is being monitored and is fully operational.
5. Trip units shall be provided with a making-current release circuit. The circuit shall be armed for approximately two cycles after breaker closing and shall operate for all peak fault levels above 25 times the ampere value of the rating plug.
6. Trip units shall have selectable thermal memory for enhanced circuit protection.
7. Trip units shall include the following individually adjustable time/current curve shaping solid-state elements:
 - a. Programmable long-time setting
 - b. Programmable long-time delay with selectable I^2t
 - c. Programmable short-time setting
 - d. Programmable short-time delay with selectable flat or I^2t curve shaping
 - e. Programmable instantaneous setting including OFF position
8. Breakers shall include interposing relay to allow for remote ARMs activation from a remote contact closure and remote indication of ARMs status via an output relay.]
9. Trip units shall provide zone interlocking for the short-time delay and ground fault delay trip functions for improved system protection and arc energy reduction. For faults within the protected zone, the zone interlocking system shall override programmed time delays to allow the upstream breaker to trip with minimal time delay.
 - a. Factory shall wire for zone interlocking for the circuit breakers within the switchgear.
10. Cause-of-trip LED indications shall include battery backup to indicate mode of trip following an automatic trip operation. A test pushbutton shall energize an LED to indicate the battery status.
11. Trip units shall have provisions for a single test kit to test each of the trip functions.
12. Advanced Trip Unit Features
 - a. Digitrip 1150+
 - a. The display for the trip units shall be a 24-character LED display.
 - b. Trip units shall be equipped to permit communication via a network twisted pair to the LAN system provided in the equipment for remote monitoring and control. All monitored parameters and statuses shall be transmitted.
 - c. Trip units shall include power, energy, and power quality metering. Metering accuracy of the complete system, including current sensors, auxiliary CTs, and the trip unit, shall be +/- 1% of full scale for current and voltage values. Metering accuracy of the complete system shall be +/- 2% of full scale for power and energy values.
 - d. The unit shall be capable of monitoring the following data:
 1. Individual phase, neutral, and ground current
 2. Voltage
 3. Minimum and maximum current values

4. Watts, Vars, VA, Watthours, Varhours, VA hours, Peak demand, Present demand, and energy consumption.
5. Crest Factor, Power Factor, Total Harmonic Distortion, and harmonic values of all phases through the 31st harmonic.
- e. The trip unit shall capture waveforms after a trip event or at the command of the user.
- f. The trip unit shall include a voltage transformer module, suitable for operation up to 600V, 50/60 Hz. The primary of the power relay module shall be connected internally to the line side of the circuit breaker through a dielectric test disconnect plug.
- g. An adjustable high load alarm shall be provided, adjustable from 50 to 100% of the long delay pickup setting.
- h. The trip unit shall contain an integral test pushbutton. A keypad shall be provided to enable the user to select the values of test currents within a range of available settings. The protection functions shall not be affected during test operations. The breaker may be tested in the TRIP or NO TRIP test mode.
- i. The trip unit shall include a power/relay module, which shall supply control power to the readout display. Following an automatic trip operation of the circuit breaker, the trip unit shall maintain the cause of trip history and the mode of trip LED indication as long as its internal power supply is available. An internal relay shall be programmable to provide contacts for remote ground alarm indication.
- j. Programming may be done via a keypad at the faceplate of the unit or via the communication network.
- k. The trip unit shall offer a three-event trip log that will store the trip data, and shall time and date stamp the event.
- l. The trip unit shall have the following advanced protective features integral to the trip unit:
 1. Adjustable undervoltage release
 2. Adjustable overvoltage release
 3. Reverse power and fault current
 4. Reverse sequence voltage alarm
 5. Underfrequency
 6. Overfrequency
 7. Voltage phase unbalance and phase loss during current detection
 8. Where the above protection(s) are not available as an integral part of the trip unit, provide separate relay(s) factory mounted and wired to a breaker shunt trip.

PART 3 EXECUTION

3.01 INSPECTION

- A. Examine existing switchboard and contact/coordinate with the equipment manufacturer to provide all equipment, devices, controls, terminations and etc. as specified and as required to properly functioning system.

3.02 INSTALLATION

- A. Install all new equipment in accordance with manufacturer's written guidelines, the NEC, and local codes.

3.03 FIELD QUALITY CONTROL

- A. Inspect completed installation for physical damage, proper alignment, anchorage, and grounding.
- B. Measure, using a Megger, the insulation resistance of each bus section phase-to-phase and phase-to-ground for one minute each, at minimum test voltage of 1000 VDC; minimum acceptable value for insulation resistance is 1 megohms. NOTE: Refer to manufacturer's literature for specific testing procedures.
- C. Check tightness of accessible bolted bus joints using calibrated torque wrench per manufacturer's recommended torque values.
- D. Physically test key interlock systems to check for proper functionality.
- E. Test ground fault systems by operating push-to-test button.

3.04 ADJUSTING

- A. Adjust all operating mechanisms for free mechanical movement per manufacturers specifications.
- B. Tighten bolted bus connections in accordance with manufacturer's instructions.
- C. Adjust circuit breaker trip and time delay settings to values as instructed by the Architect/Engineer.

3.05 CLEANING

- A. Touch up scratched or marred surfaces to match original finish.

END OF SECTION

SECTION 26 2726
WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Receptacles, receptacles with integral GFCI, and associated device plates.
 - 2. Wall-box motion sensors.
 - 3. Snap switches and wall-box dimmers.
 - 4. Solid-state fan speed controls.
 - 5. Wall-switch and exterior occupancy sensors.
 - 6. Communications outlets.
- B. See Division 27 Section "Communications Horizontal Cabling" for workstation outlets.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
- C. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.3 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. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:

PROJECT No. 71-19-4365-01
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WIRING DEVICES

1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
3. Leviton Mfg. Company Inc. (Leviton).
4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

2.2 STRAIGHT BLADE RECEPTACLES

- A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 5351 (single), 5352 (duplex).
 - b. Hubbell; HBL5351 (single), CR5352 (duplex).
 - c. Leviton; 5891 (single), 5352 (duplex).
 - d. Pass & Seymour; 5381 (single), 5352 (duplex).

2.3 GFCI RECEPTACLES

- A. General Description: Straight blade. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.
- B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; GF20.
 - b. Pass & Seymour; 2084.

2.4 SNAP SWITCHES

- A. Comply with NEMA WD 1 and UL 20.
- B. Switches, 120/277 V, 20 A:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 2221 (single pole), 2222 (two pole), 2223 (three way), 2224 (four way).

- b. Hubbell; CS1221 (single pole), CS1222 (two pole), CS1223 (three way), CS1224 (four way).
 - c. Leviton; 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way), 1224-2 (four way).
 - d. Pass & Seymour; 20AC1 (single pole), 20AC2 (two pole), 20AC3 (three way), 20AC4 (four way).
- C. Pilot Light Switches, 20 A:
- 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 - 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 2221PL for 120 V and 277 V.
 - b. Hubbell; HPL1221PL for 120 V and 277 V.
 - c. Leviton; 1221-PLR for 120 V, 1221-7PLR for 277 V.
 - d. Pass & Seymour; PS20AC1-PLR for 120 V.
 - 3. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."
- D. Key-Operated Switches, 120/277 V, 20 A:
- 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 - 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 2221L.
 - b. Hubbell; HBL1221L.
 - c. Leviton; 1221-2L.
 - d. Pass & Seymour; PS20AC1-L.
 - 3. Description: Single pole, with factory-supplied key in lieu of switch handle.
- E. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.
- 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 - 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 1995.
 - b. Hubbell; HBL1557.
 - c. Leviton; 1257.
 - d. Pass & Seymour; 1251.

- F. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 1995L.
 - b. Hubbell; HBL1557L.
 - c. Leviton; 1257L.
 - d. Pass & Seymour; 1251L.

2.5 WALL-BOX DIMMERS

- A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
- B. Control: Continuously adjustable slider; with single-pole or three-way switching. Comply with UL 1472.
- C. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.
1. 600 W; dimmers shall require no derating when ganged with other devices. Illuminated when "OFF."
- D. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.6 FAN SPEED CONTROLS

- A. Modular, 120-V, full-wave, solid-state units with integral, quiet on-off switches and audible frequency and EMI/RFI filters. Comply with UL 1917.
1. Continuously adjustable slider 5 A.
 2. Three-speed adjustable slider 1.5 A.

2.7 COMMUNICATIONS OUTLETS

- A. Telephone Outlet:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 3560-6.
 - b. Leviton; 40649.
3. Description: Single RJ-45 jack for terminating 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1 complying with Category 5e. Comply with UL 1863.

B. Combination TV and Telephone Outlet:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 3562.
 - b. Leviton; 40595.
3. Description: Single RJ-45 jack for 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e; and one Type F coaxial cable connector.

2.8 WALL PLATES

- A. Single and combination types to match corresponding wiring devices.
1. Plate-Securing Screws: Metal with head color to match plate finish.
 2. Material for Finished Spaces: Smooth, high-impact thermoplastic 0.035-inch-(1-mm-).
 3. Material for Unfinished Spaces: Galvanized steel
 4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations."
- B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, die-cast aluminum with lockable cover.

2.9 FLOOR SERVICE FITTINGS

- A. Type: Modular, flush-type, dual-service units suitable for wiring method used.
- B. Compartments: Barrier separates power from voice and data communication cabling.
- C. Service Plate: Rectangular, die-cast aluminum with satin finish.
- D. Power Receptacle: NEMA WD 6 configuration 5-20R, gray finish, unless otherwise indicated.
- E. Voice and Data Communication Outlet: Blank cover with bushed cable opening or two modular, keyed, color-coded, RJ-45 Category 5e jacks for UTP cable – As indicated on drawings.

2.10 FINISHES

- A. Color: Wiring device catalog numbers in Section Text do not designate device color.
 - 1. Wiring Devices Connected to Normal Power System: As selected by Architect, unless otherwise indicated or required by NFPA 70 or device listing.
 - 2. Wiring Devices Connected to Emergency Power System: Red.
 - 3. TVSS Devices: Blue.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.
- B. Coordination with Other Trades:
 - 1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
 - 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 - 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 - 4. Install wiring devices after all wall preparation, including painting, is complete.
- C. Conductors:
 - 1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
 - 2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 - 3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
 - 4. Existing Conductors:
 - a. Cut back and pigtail, or replace all damaged conductors.
 - b. Straighten conductors that remain and remove corrosion and foreign matter.
 - c. Pigtailling existing conductors is permitted provided the outlet box is large enough.
- D. Device Installation:

1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

3.2 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."

1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
 - 1. Test Instruments: Use instruments that comply with UL 1436.
 - 2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

- B. Tests for Convenience Receptacles:
 - 1. Line Voltage: Acceptable range is 105 to 132 V.
 - 2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
 - 3. Ground Impedance: Values of up to 2 ohms are acceptable.
 - 4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
 - 5. Using the test plug, verify that the device and its outlet box are securely mounted.
 - 6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new, and retest as specified above.

END OF SECTION

SECTION 26 2813
FUSES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Cartridge fuses rated 600-V ac and less for use in control circuits, enclosed switches, enclosed controllers and motor-control centers.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Operation and maintenance data.

1.3 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. Comply with NEMA FU 1 for cartridge fuses.
- C. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper Bussmann, Inc.
 - 2. Edison Fuse, Inc.
 - 3. Ferraz Shawmut, Inc.
 - 4. Littelfuse, Inc.

2.2 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

PART 3 - EXECUTION

3.1 FUSE APPLICATIONS

- A. Motor Branch Circuits: Class RK5, time delay.
- B. Other Branch Circuits: Class RK5, time delay.

3.2 INSTALLATION

- A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.3 IDENTIFICATION

- A. Install labels complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block and holder.

END OF SECTION

SECTION 26 2816
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Fusible switches.
 - 2. Nonfusible switches.
 - 3. Molded-case circuit breakers (MCCBs).
 - 4. Enclosures.

1.2 DEFINITIONS

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

1.3 SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated.
- 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.
- C. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.
- D. Field quality-control reports.
- E. Operation and maintenance data.

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. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.
- B. Type HD, Heavy Duty, Single Throw, 240V or 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.
- C. Type HD, Heavy Duty, Six Pole, Single Throw, 240V or 600V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- D. Type HD, Heavy Duty, Double Throw, 240V or 600V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- E. Accessories:
 - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 - 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 - 3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
 - 4. Lugs: Suitable for number, size, and conductor material.
 - 5. Service-Rated Switches: Labeled for use as service equipment.

2.2 NONFUSIBLE SWITCHES

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

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.
- B. Type HD, Heavy Duty, Single Throw, 240 or 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.
- C. Type HD, Heavy Duty, Six Pole, Single Throw, 240V or 600V ac, 200 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.
- D. Type HD, Heavy Duty, Double Throw, 240V or 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.
- E. Accessories:
1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 3. Lugs: Suitable for number, size, and conductor material.

2.3 MOLDED-CASE CIRCUIT BREAKERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.
- B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.
- C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- D. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
1. Instantaneous trip.
 2. Long- and short-time pickup levels.

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ENCLOSED SWITCHES AND CIRCUIT BREAKERS

3. Long- and short-time time adjustments.
 4. Ground-fault pickup level, time delay, and I²t response.
- E. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.
- F. Features and Accessories:
1. Standard frame sizes, trip ratings, and number of poles.
 2. Lugs: Suitable for number, size, trip ratings, and conductor material.
 3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
 4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
 5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
 6. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 7. Alarm Switch: One NO contact that operates only when circuit breaker has tripped.

2.4 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. Kitchen Areas: NEMA 250, Type 4X
 4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
 5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

PART 3 - EXECUTION

3.1 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 Division 26 Section "Vibration and 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.

3.2 IDENTIFICATION

- A. Comply with requirements in Division 26 Section "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.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- 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.
- 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.

END OF SECTION

