CONTRACT DOCUMENTS AND TECHNICAL SPECIFICATIONS

Schedule I
Existing Terminal Holdroom Renovation

Schedule II
Terminal Holdroom Addition

VOLUME 2: Specification Divisions 20-33 and Civil

Local Project No. PFC/LOC 19-01

Casper, Wyoming

Sponsored By:
Casper/Natrona County International Airport Board of Trustees

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Issued For Bid
April 9, 2020
SECTION 00 0107
DESIGN PROFESSIONAL SEALS

A. As a matter of consistency, completeness, and convenience, this bound set of Project documents includes designs prepared by Architect in addition to designs prepared by other consultants who have provided services as independent design professionals.

B. For purposes of graphic consistency, uniformity, and ease of reference, Project documents may be presented on plan sheets or in the Project Manual containing Architect's title blocks or page formats. The works of each design discipline are separately identifiable, and each design professional exclusively retains professional responsibility for the designs prepared by that design professional.

1.02 CERTIFICATIONS

A. Each of the design firms listed below certify that they have prepared or directly supervised the preparation of their respective Drawings and Specifications, and that each is currently and legally licensed as an Architect or Engineer in Wyoming.

B. Each of the design firms below is responsible only for the content of the Drawings and Specifications which were prepared by each design firm, as briefly described below each seal, and does not accept responsibility for the content of any Drawings or Specifications which were not prepared by each design firm.

Name: Jviation, Inc.  
Firm: Jviation, Inc.  
Design Responsibility: Site Layout  

Name: MOA ARCHITECTURE  
Firm: MOA ARCHITECTURE  
Design Responsibility: Architecture  

Name: CEPI  
Firm: CEPI  
Design Responsibility: Civil Engineering  

Name: KL&A  
Firm: KL&A  
Design Responsibility: Structural Engineering
Name:  
Firm: Engineering Design Associates  
Design Responsibility: Mechanical Engineering

Name:  
Firm: Engineering Design Associates  
Design Responsibility: Electrical Engineering
SECTION 20 0050
COMMON PLUMBING AND HVAC

PART 1 GENERAL

1.01 SCOPE OF WORK

A. The work to be performed under the Plumbing and HVAC sections of the specification shall include all supervision, labor, equipment, and materials required and incidental to providing and installing complete and adjusted engineered systems, as shown on the drawings and described herein.

B. All specification requirements shall be considered complementary to other specification sections for the project. Where conditions of this section conflict with bidding instructions and/or other general conditions, the contractor shall request clarification thru the design team prior to bidding the work.

C. The contractor shall plan the work in advance and coordinate all installation requirements with other trades. Contractors shall be held to have checked all construction documents for possible interference caused by work of other trades, conditions of the premises, and obstructions. Where conflicts occur, the contractor shall request clarification through the prime or general contractor.

D. Note that the term “general contractor” as used thru-out these specifications may apply to a prime contractor, or a construction manager, or another term as appropriate for the particular delivery method. Where the primary contract holder is not performing the function of a general contractor, the term will apply to this contractor.

1.02 INTENT AND RESPONSIBILITY

A. Execution of the work shall be governed by the construction documents: architectural, structural, plumbing, hvac, and electrical drawings, where applicable, as well as drawings of associated trades. Locations of piping, equipment, ducts, etc. on the drawings are diagrammatic; indicated positions shall be followed as closely as possible, however exact locations shall be subject to building construction conditions and interferences with other work.

B. Before fabrication, piping and ductwork shall be checked with the building construction for dimensions, locations, clearances, etc. Ductwork and piping shall be made up with the necessary variations to conform to the details of the construction of the building. Ductwork and piping that is made up before hand and found that it will not fit into allocated spaces shall be re-constructed at no additional expense to the project.

1.03 CODES, RULES, PERMITS, AND FEES

A. Materials furnished and work installed shall comply with all state and locally adopted nationally recognized and consolidated building codes and standards, with requirements of local utility companies, and with the requirements of all governmental authorities having jurisdiction.

B. The contractor shall give all necessary notices, obtain all permits and pay all sales taxes, fees, and other costs, including utility connections or extensions, in connection with his work; file all necessary plans, prepare documents and obtain all necessary approvals of governmental departments having jurisdiction; obtain all required certificates of inspection and deliver same to the engineer before request for acceptance and final payment.

C. The contractor shall include in the work, without extra cost to the owner, any labor, materials, services, apparatus, etc. in order to comply with all applicable laws, ordinances, rules and
regulations, whether indicated or not on the drawings. Where materials or installations that are specified or detailed in a way that conflicts with or is perceived to conflict with governing requirements, the contractor shall request clarification from the design team prior to bidding.

1.04 CONSTRUCTION DRAWINGS

A. The drawings and the specifications are intended to be complimentary. Where conflicts exist on the drawings or between the drawings and the specifications, and the contractor fails to notify the engineer prior to issuance of the final addendum, the contractor will be held to have considered and included the most expensive option in the bid. No changes or extras will be given for one option over the other.

B. Drawings indicate suggested routing of pipes, ducts, and other conduits. It is not intended that drawings indicate all offsets that may be necessary to avoid conflicts with structure, work of other trades, or other conduits. The contractor shall plan installation to conform to the structure, avoid obstructions, and preserve clearance, without additional cost to the project.

C. Drawings are diagrammatic and generally indicative of the work. The contractor shall follow the drawings in laying out work and check drawings of other trades to verify spaces in which work will be installed. Confirm conditions in the field and coordinate with other trades prior to rough-in. All equipment shall be installed such that access is maintained for serviceability.

D. Maintain maximum headroom and space conditions at all points. Where headroom or space conditions appear inadequate, the engineer shall be notified before proceeding with installation to prevent conflict with work of other trades and for proper execution of the work.

1.05 SURVEYS AND MEASUREMENTS

A. The contractor shall base all measurements, both horizontal and vertical from established benchmarks. All work shall agree with these established lines and levels. Verify all measurements on site and check the correctness of same as related to the work.

B. Should any discrepancy be discovered between actual measurements and those indicated, which prevents following good practice or the intent of the drawings, the contractor shall request clarification through the general contractor, and shall not proceed with the work until instructions are received from the design team.

1.06 SUBSTITUTIONS

A. See Division 01 General Requirements, for additional substitution procedures.

B. A specification in which a manufacturer's product is named and accompanied by the words "basis of design", including make or model number or other designation, shall establish significant qualities and other characteristics for purposes of evaluating comparable products of additional manufacturers.

C. Where specifications name a basis of design product, or refer to a basis of design product indicated on the drawings, and other products or manufacturers are not listed, provide the specified or indicated product or an approved comparable product. Equipment scheduled on the drawings shall be considered the "basis of design".

D. Wherever the word "equal", or words to the same effect are used in connection with a specified product, it is to be understood that such words mean any product claimed to be an equal shall be reviewed and accepted in writing by the engineer. Products and materials not specifically identified as accepting "equals", and which have not been submitted for prior review, will be summarily rejected.
E. Pre-bid requests for substitution must be received by the engineer one calendar week prior to the bid date (or as otherwise specified in the instructions to bidders), so that they may be processed and included by addendum for the benefit of all bidders. Requests received after the deadline will not be considered. A substitution request form must accompany each individual application with undersigned certification as described below.

F. Requests shall indicate the paragraphs and/or drawing details from which the proposed construction and/or function varies from the items specified, and shall provide complete data showing and explaining all such changes or variations the bidder proposes to make from the drawings and specifications.

G. It is further understood that no material or work shall be presented to the engineer as equal to that specified without the full understanding on the part of the manufacturer, the supplier, and the contractor, that the engineer is to use his own judgment in determining equivalency, and the decision is final.

1.07 SUBSTITUTION REQUESTS

A. Document each request with complete point-by-point comparative data substantiating compliance of the proposed substitution with the contract documents. Submit shop drawings, product data, etc, attesting to the proposed product equivalence. Burden of proof is on the proposer. Clearly indicate all salient points.

B. A request for substitution constitutes a representation that the submitter certifies the following:
   1. Proposed product has been fully investigated and determined to be equal or superior in all respects to specified product.
   2. Proposed product is consistent with the design and/or design intent and will not require revisions to the contract documents.
   3. Proposed product is compatible with other portions of the work, and will produce the intended results.
   4. Proposed product will not affect dimensions and functional clearances, and will have no adverse effects on other trades.
   5. Claims for additional costs or time extension that may subsequently become apparent will be waived.
   6. Payment will be made to the design team and/or other trades for changes to building design and/or construction.

C. Equipment may have been originally selected with certain capabilities for safety factor, future considerations, adjustment beyond scheduled values, etc. Substituted equipment submitted as equal shall be capable of achieving the basis of design performance and/or capacities, regardless of how it is scheduled.

D. Acceptance of a proposed product manufacturer prior to bidding does not constitute final acceptance of the substitution to imply that it meets all specific and significant qualities of the scheduled or specified product. The specified product shall remain the “basis of design” and all accepted substitute product manufacturers remain subject to requirements therein.

E. The proposed substitutions shall be inclusive of all cost and physical implications throughout the project. Under no circumstances should the substitution result in added cost to the project. Should the substitution be approved neither the project specifications nor the drawings will be revised to reflect the substitution.
1.08 EQUIPMENT DEVIATIONS

A. Where the contractor has proposed to use an item or equipment other than that specified or detailed on the drawings, which requires any redesign of the structure or any other part of the design, all such redesign, and all new drawings and detailing required thereof, shall be prepared by the contractor at his own expense and submitted for approval by the engineer.

B. Where such accepted deviation requires a different quality, capacity, or arrangement of related equipment, ductwork, piping, wiring, or conduit from that specified or indicated on the drawings, the contractor shall furnish and install all such material and equipment required at no additional cost and with no additional time added to the contract.

1.09 SUBMITTALS FOR REVIEW

A. See Division 01 General Requirements, for additional submittal procedures.

B. Prior to delivery of any equipment or material to the jobsite, the contractor shall submit for review, detailed shop drawings and/or product data cut sheets of all equipment and materials required to complete the project. No material or equipment may be delivered to the jobsite or installed until the contractor has in his possession the reviewed submittals for the particular material or equipment.

C. Submittals shall include detailed, dimensioned cut sheets showing manufacturer, model, construction, quantity, size, arrangements, operating clearances, performance characteristics, and capacity. Each item of equipment proposed shall be a standard catalog product or custom modified version of an established manufacturer, and of equal quality, fit, finish, durability, and performance to those specified or scheduled.

D. Unless otherwise approved in advance, all submittals and resubmittals for each division shall be transmitted to the engineer at one time. Submittals shall be transmitted sufficiently in advance to allow ample time for review. Review will not commence until all submittals for a particular division are received. Partial submittals will be returned without review. Failure to submit with ample time for checking shall not entitle an extension of contract time.

E. Samples, drawings, specifications, catalogs, etc submitted for review, shall be properly labeled indicating contractors name and title of project, section/article number of specifications governing, and specific service and size range for which material or equipment is to be used, with model numbers and accessories clearly marked.

F. The purpose of submittals is to demonstrate the way by which the contractor proposes to conform to information given in the contract documents. There is no alleged responsibility of the engineer for failing to catch the contractor's errors in submittals.

G. The work shall be in accordance with approved submittals, except that the contractor shall not be relieved of responsibility for deviations from requirements of the contract documents by the engineer's approval of shop drawings, product data, or other submittals.

H. Review rendered shall not be considered as a guarantee of building conditions. The contractor is responsible for dimensions, which shall be confirmed at the job site; coordination of his work with that of other trades, quantities required, and the satisfactory performance of his work.

1.10 DIGITAL SUBMITTALS

A. At the contractor's option, paperless electronic submittals may be transmitted in an Adobe PDF formatted file. Electronic submittals and resubmittals are subject to all outlined requirements listed above. Additionally:
1. When submitting individual files, transmit in logical grouping with each specification number and title (and article or paragraph number where applicable) identified in the file name.

2. When submitting large combined PDF files, group products under separate cover sheets and identify each with the specification number and title (and article where applicable). Files with loose pages will be rejected.

B. When resubmitting, transmit the full and complete submittal section, such that a single reviewed and accepted submittal file will exist on the record and with the general contractor on the jobsite. Partial resubmittals and/or loose sheets will be rejected.
   1. Remove all rejected pages, pages not applicable to the submittal, and/or pages that are being changed for the resubmittal. Insert all new pages into the digital file in the appropriate locations, labeled and indicated as specified above.
   2. Return the digital file with the same or similar identifying file name, including the specification section number and title, and article or paragraph numbers where applicable.

C. Where these instructions are not followed, all submittals will be summarily rejected. Each contractor is wholly responsible providing properly formatted submittals with sufficient time for review.

1.11 DELEGATED DESIGN SUBMITTALS

A. Where indicated, the contractor shall provide professional services or certifications by a properly licensed design professional, whose signature and seal shall appear on all drawings, calculations, specifications, certifications, shop drawings, and other submittals prepared by such professional.

B. Shop drawings and other submittals related to the work designed or certified by such professional, if prepared by others, shall bear such professional’s written approval when submitted for review.

C. The Owner and the engineer shall be entitled to rely upon the adequacy, accuracy, and completeness of the services, certifications, and approvals performed or provided by such design professionals.

D. The engineer will review, approve, or take other appropriate action on submittals only for the limited purpose of checking for conformance with the information given and the design intent expressed in the contract documents.

E. Work on the project shall not begin until submittals have been accepted by the engineer, and the Authority Having Jurisdiction where applicable.

1.12 COOPERATION WITH OTHER TRADES

A. This contractor shall give full cooperation to other trades and shall furnish in writing to said trades, with copies to the engineer, any information necessary to permit the work of all trades to be installed satisfactorily and with the least possible interference or delay.

B. Where the work of the contractor will be installed in close proximity, or will interfere with work of other trades, he shall assist in working out space conditions to make a satisfactory adjustment. In general, sanitary waste and vent and roof drains shall have precedence; ductwork shall have precedence over all other plumbing and piping, piping shall have precedence over conduit, etc.

C. If so directed by the engineer, the contractor shall prepare composite working drawings and sections at a suitable scale not less than a quarter inch, clearly showing how his work is to be installed in relation to the work of other trades. If the contractor installs his work before coordinating with other trades, so as to cause any interference with work of other trades, he shall make the necessary changes in his work to correct the condition without extra charge.
D. The contractor shall furnish other trades all necessary templates, patterns, setting plans, and shop details for the purpose of coordinating adjacent work or for the proper installation of common work and equipment.

1.13 MATERIAL AND WORKMANSHP

A. All material and apparatus required for the work, except as specified otherwise, shall be newly manufactured, of best quality, and shall be furnished, delivered, erected, connected and finished in every detail. Where no specific kind of quality of material is given, a best-in-class standard article as approved by the engineer shall be furnished.

B. The contractor shall furnish the services of an experienced superintendent, who shall be continuously in charge of the installation of the work, together with all skilled workmen, fitters, metal workers, welders, helpers, and labor required to unload, transfer, erect, connect, adjust, start, operate, and test each system.

1.14 GUARANTEES AND WARRANTIES

A. The contractor shall guarantee, in writing, that all work installed will be free from any and all defects in workmanship and/or materials; that all apparatus will develop capacities and characteristics specified; and that if, during a period of one year, or as otherwise specified from the date of substantial completion, any such defects in workmanship, material or performance appear, the contractor will remedy such defects within a reasonable time and without cost to the owner.

B. The contractor or manufacturer shall guarantee that individual items or groups of items furnished shall have capacities equal to or greater than that specified and shall be suitable for the intended application. Furnish manufacturer's written warranties on all equipment to the owner stating effective date of warranty.

C. In default thereof, the Owner may have such work done and charge costs to the contractor.

1.15 MANUFACTURER'S SPECIFICATIONS

A. Where these specifications require that a material, article, or apparatus shall be applied, installed, assembled, connected, cleaned, started, etc., "in accordance with the manufacturer's specifications, directions, or recommendations", said instructions shall have the same force and effect as though written in full in these specifications.

PART 2 EXECUTION

2.01 EXCAVATION AND TRENCHING

A. Mass excavation to approximate building levels will be carried out under a section of the architectural specifications. Except as otherwise noted on drawings, this contractor shall be responsible for trench and pit excavations and backfilling required for work under this section of the specifications, inside and outside the building, including all required shoring, bracing, and/or pumping, and all protection for safety of persons and property. Local or state safety codes shall be strictly observed.

B. It shall be the responsibility of this contractor to check the indicated elevations of utilities entering and leaving the building. If such elevations require excavations lower than the footing levels, the engineer shall be notified of such conditions and approval shall be made before excavations are commenced. It is also the responsibility of the contractor to make excavations at the minimum required depths and locations to prevent undercutting the footing.
C. Verify locations of all existing and/or new underground utilities prior to trenching and, if damaged by this contractor, replace immediately in an approved manner and at no expense to the project. Piping and electrical work shall not be installed in the same ditch.

D. When rock is encountered during excavation, it shall be addressed as outlined under the architectural section of these specifications.

2.02 HANDLING AND PROTECTION

A. The contractor shall protect all work and material from damage by his work or workmen, and shall be liable for all damage thus caused. The contractor shall be responsible for work and equipment until finally inspected, tested, and accepted. The contractor shall protect material and equipment received on site which is not immediately installed.

B. All open ends of piping, ducts, and equipment shall be closed with temporary covers or plugs during storage and construction to prevent entry of dirt or obstructing material. Where this has not been done, the contractor shall provide cleaning services at no additional cost to the project.

2.03 ACCESSIBILITY AND PANELS

A. The contractor shall be responsible for the size of shafts and chases, and adequate clearance in partitions and ceiling space for the proper installation of the work. Advise the general contractor of any requirements and cooperate with all other trades whose work is in the same space, and shall advise the general contractor of his requirements. Such spaces and clearances shall be kept to the minimum size required.

B. The contractor shall locate all equipment which must be serviced, operated, or maintained in fully accessible positions. Accessible equipment shall include but not be limited to, fire and smoke dampers, volume dampers, coils, valves, traps, clean-outs, motors, controllers, and drain points. Provide NEC clearances at all electrical equipment and controls.

C. Furnish metal access panels with screwdriver cam-locking device of required size and type to provide access to devices concealed in walls, ceilings, or furred-in spaces. Furnish access panels to the general contractor for installation as directed by this contractor. Location of these panels shall be communicated in sufficient time to be installed in the normal course of work.

D. Panel size shall be minimum 12" x 12" and larger as conditions may demand. Panels shall be of the type necessary for the particular wall or ceiling construction in which they occur and shall be approved for fire-rated assemblies where required. See architectural specifications for panel types.

2.04 FOUNDATIONS AND SUPPORTS

A. The general contractor will install concrete equipment pads. Pads shall be placed under all pumps, compressors, other rotating machinery, and where indicated. All pads shall extend 6-inches beyond the machine base in all directions, with the top edge chamfered. Reinforce per the structural specifications.

B. All equipment, unless shown otherwise, shall be securely attached to the building structure in an approved manner. Attachments shall be of a strong and durable nature and any attachments that are, in the opinion of the engineer, not strong enough shall be replaced as directed.

C. This contractor shall furnish all temporary equipment such as ladders, scaffolding, rigging, hoisting, and services necessary for proper and safe execution of the work, and delivery onto the premises of any equipment and apparatus furnished.
2.05 CUTTING AND PATCHING

A. The general contractor shall provide for all openings in construction. The mechanical contractor shall coordinate sizes and locations of openings and shall be responsible for all cutting and patching as necessary when sizes or locations are incorrectly communicated to the general contractor. Patching shall match adjacent surfaces. No structural members shall be cut without the approval of the engineer, and all such cutting shall be done in a manner directed by him.

B. Damages to new and existing masonry or brick veneers as the result of cutting or core drilling for penetrations of ductwork, grilles, louvers, piping, etc shall be repaired by an independent contractor without additional cost to the owner. Said contractor shall be regularly engaged in the masonry business with documented experience of at least five years.

2.06 SLEEVES AND PLATES

A. Sleeves shall be provided for all piping passing through concrete floor slabs and masonry, tile, gypsum, and concrete wall construction. Locate all sleeves and inserts required before the floors and walls are built, or be responsible for the cost of cutting and patching required for pipes where sleeves and inserts penetrate existing construction, or where they were not installed or incorrectly located.

B. Where pipe motion due to expansion and contraction will occur, make sleeves of sufficient diameter to permit free movement of pipe. Where sleeves pass insulated pipes the sleeves shall be large enough to pass the pipe only and the insulation shall be made to butt against the construction.

C. Where sleeves are located in fire-rated assemblies, fill space between pipe and sleeve with a listed and approved “fire stop” material. Where sleeves are placed in exterior walls, the space between the pipe and the sleeve shall be sealed with a weather tight caulk.

D. Check floor and wall construction finishes to determine proper length of sleeves for various locations. Terminate sleeves flush with walls, partitions and ceilings. In chase areas where pipes are concealed, terminate sleeves flush with floor. In all mechanical rooms and chases where pipes are exposed, extend sleeves 2-inches above finished floor.

E. Fasten sleeves securely in floors and walls, so that they will not become displaced when concrete is poured or when other construction is built around them. Take precautions to prevent concrete, plaster, or other materials being forced into the sleeve during construction.

F. Escutcheon plates shall be provided for all exposed uninsulated pipes passing through walls, floors, and ceilings. Plates shall be nickel plated, of the spring ring type, sized to match the pipe. Where plates are provided for pipes passing through sleeves that extend above the floor surface, provide deep recessed plates to conceal the pipe sleeves.

2.07 FIRE SAFE SEALANTS

A. Provide and install an elastomeric sealant formulated for use in a through-penetration fire-stop system for filling openings around duct and piping penetrations through walls and floors, and having a UL tested and approved fire-resistance rating for the intended construction.

2.08 LUBRICATION OF EQUIPMENT

A. The contractor shall properly lubricate all pieces of equipment before turning the building over to the owner. A tag shall be attached to each motor showing the date of lubrication and lubricant needed.
2.09 QUIET OPERATION AND VIBRATION

A. All work shall operate under all conditions of load without any sound or vibration which is objectionable in the opinion of the engineer. In the case of moving machinery, sound or vibration noticeable outside the room where the equipment is located, will be considered objectionable.

B. Conditions shall be corrected in an approved manner by the contractor at no additional cost to the project. Vibration control shall be by means of approved vibration eliminators in a manner as recommended by the manufacturer of the eliminators.

2.10 MOTORS

A. Motors shall be built in accordance with the latest NEMA standards and as specified. Motors shall be tested in accordance with standards of ASA C50 and conform thereto for insulation resistance and dielectric strength.

B. Each motor shall be provided with a conduit terminal box and adequate starting and protective equipment as specified or required. The capacity shall be sufficient to operate associated driven devices under all conditions of operations and load without overload, at the horsepower indicated or specified.

C. All motors rated greater than 1000 watts shall have a power factor of not less than 85% at rated load.

2.11 ELECTRICAL CONNECTIONS

A. The electrical contractor will furnish and install all wiring except temperature control wiring, equipment control wiring which does not conduct full load motor current, and interlock wiring. The electrical contractor will furnish and install all power wiring complete from power source to motor or equipment junction box, including power wiring through starters.

B. The electrical contractor will furnish and install all starters not factory mounted on equipment.

C. Control relay and control transformers shall be furnished under the mechanical contract except where furnishing such items is specifically required under the electrical specifications and/or drawings.

PART 3 CLOSEOUT

3.01 CLEANING AND FINISHING

A. The contractor shall go over the work and clean all equipment, ductwork, fixtures, piping, etc. Wipe down exterior surfaces, vacuum, wash, and clean interiors of all fan cabinets, air handlers, etc.

B. The contractor shall clean all dirt and debris from mechanical spaces, within and around all equipment (regardless of fault, pre-condition, or who the mess belongs to).

3.02 SYSTEM OPERATION

A. The contractor shall provide allowance in his bid to demonstrate that each system operates according to the specification. The contractor shall arrange to have all subcontractors (temperature control, sheet metal, plumbing, balancing, etc.) available to demonstrate to the engineer that each system performs properly.
B. If the equipment is installed improperly, is found to be faulty, or the contractor's personnel or subcontractors are not available and the demonstration requires more than one visit to the site, this contractor shall be responsible for additional time incurred by the engineer and agrees that the owner may deduct hourly fees from the amount otherwise due the contractor.

3.03 RECORD DRAWINGS

A. The contractor shall maintain a complete set of plumbing and mechanical drawings at the site, with all changes, etc, marked neatly thereon in a contrasting color. This set shall not be used for any other purpose. Keep the drawings current at all times.

B. At the completion of the project, the contractor shall record all changes on a clean set of drawings and present this set to the engineer. This set shall be dated and clearly marked "Record Drawings".

3.04 OPERATING INSTRUCTIONS

A. Upon completion of all work and all tests, the contractor and his subcontractors shall furnish the necessary skilled labor and helpers for demonstrating operation of the system and equipment for at least one 8-hour day, or as otherwise specified in individual sections.

B. During this period, instruct the Owner or his representative fully in the operation, adjustment, and maintenance of all equipment furnished. Give at least one week notice to the Owner and the engineer in advance of this period.

3.05 MAINTENANCE MANUAL

A. This contractor shall furnish a minimum of three (3) operation and maintenance manuals. Each manual shall include a title sheet showing the engineering firm, general contractor, plumbing contractor, sheet metal contractor, and temperature control contractor. List phone numbers and addresses for all firms. Each manual shall also consist of the following, but is not limited to:

1. Table of contents.
2. Mechanical written guarantees.
3. List of all mechanical equipment suppliers.
4. Maintenance items and frequency of maintenance.
5. Written sequence of equipment operation (general description).
6. Equipment shop drawings and manufacturer service books.
7. Temperature control schematics.
8. Balancing and start-up reports.
9. Cleaning and treatment certifications.
10. Air and water filter replacement list.
11. Plumbing fixture shop drawings.
12. Parts list on all faucets and flush valves.

B. The contractor shall supply all shop drawings, part lists, and manufacturer's operation and maintenance literature. All type written pages shall be inserted in "plastic sheet protectors" and each section separated with tabbed dividers. Three-ring or D-ring "presentation type" binders shall be used, with the project title and date in protected plastic sleeves under the cover and the end.
C. Paperless operation and maintenance manuals will be accepted with prior approval from the engineer. Manuals shall be submitted in a single, bound, Adobe PDF formatted file, complete with all outlined sections and requirements listed above. Multiple loose files will not be acceptable.

END OF SECTION
SECTION 20 0517
SLEEVES AND SEALS

PART 1 GENERAL

1.01 SECTION INCLUDES
A. Sleeves.
B. Sleeve-seal systems.

1.02 RELATED REQUIREMENTS
A. Specifications throughout all divisions of the project manual are directly applicable to this section, and this section is directly applicable to them.

1.03 ACTION SUBMITTALS
A. Product Data: Provide manufacturer’s catalog literature for each for each type of product indicated.

1.04 COORDINATION
A. Coordinate installation of sleeves with size, location, and installation of service utilities.
B. Coordinate installation of sleeves with the installation of concrete walls, masonry walls, and concrete floor and roof slabs.

PART 2 PRODUCTS

2.01 SLEEVE-SEAL SYSTEMS
A. Manufacturers: Subject to compliance with requirements, available manufacturers that may be incorporated into the work include, but are not limited to the following:
   3. Pipeline Seal and Insulator, Inc; gptindustries.com.
B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
C. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
D. Pressure Plates: Carbon steel.
E. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.02 SLEEVES
A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral water-stop unless otherwise indicated.
B. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

C. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to forms.

PART 3 EXECUTION

3.01 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in concrete and masonry walls, concrete floors, and concrete roof slabs as new walls and slabs are constructed.
   1. Extend sleeves installed in floors of mechanical equipment areas, plumbing and piping chases, or other wet areas 2 inches above finished floor level.
   2. In all other locations, cut sleeves to length for mounting flush with both surfaces. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
   3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
   4. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint.

B. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials.

C. Escutcheon Plates: Install one-piece or split hinge metal plates for pipes passing through floors, walls, and ceilings in exposed areas. Provide polished stainless steel or chrome plated escutcheons in finished spaces and metal plates with paint finish in unfinished areas.

3.02 SLEEVE-SEAL SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building. Sleeves are not required for core drilled holes.
   1. Select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls. Sleeves are not required for core drilled holes.
   2. Select type, size, and number of sealing elements required for piping material and size, and for sleeve ID or hole size.
   3. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve.
   4. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.03 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Exterior Concrete Walls below Grade:
   1. Piping NPS 6 and Smaller: Cast-iron wall sleeves with sleeve-seal system.
   2. Piping Larger than NPS 6: Not applicable.

B. Concrete Slabs-on-Grade:
   1. Piping NPS 6 and Smaller: Cast-iron wall sleeves with sleeve-seal system.
   2. Piping Larger than NPS 6: Not applicable.

C. Concrete and Masonry Walls above Grade:
   1. Piping NPS 6 and Smaller:
SLEEVES AND SEALS

a. Cast-iron wall sleeves.
b. Galvanized-steel-pipe sleeves.

2. Piping Larger than NPS 6: Not applicable.

D. Concrete Slabs above Grade:
   1. Piping NPS 6 and Smaller:
      a. Galvanized-steel-pipe sleeves for wet areas.
      b. Molded-PE or -PP sleeves for all others.
   2. Piping Larger than NPS 6: Not applicable.

END OF SECTION
PART 1 GENERAL

1.01 SECTION INCLUDES
   A. Liquid-in-glass thermometers.
   B. Thermal wells.
   C. Dial-type pressure gages.
   D. Gage attachments.
   E. Test plugs.
   F. Test-plug kits.

1.02 RELATED REQUIREMENTS
   A. Specifications throughout all divisions of the project manual are directly applicable to this section, and this section is directly applicable to them.

1.03 ACTION SUBMITTALS
   A. Product Data: Provide manufacturer’s catalog literature for each for each type of product indicated.

1.04 COORDINATION
   A. Coordinate installation of meters and gauges with installation of piping and ductwork.

PART 2 PRODUCTS

2.01 LIQUID-IN-GLASS THERMOMETERS
   A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the work include, but are not limited to the following:
      1. Miljoco Corporation; miljoco.com
      2. Trerice Company; trerice.com
      3. Weiss Instruments; weissinstruments.com
   B. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
      2. Case: Cast aluminum; 9-inch nominal size unless otherwise indicated.
      3. Case Form: Adjustable angle unless otherwise indicated.
      4. Tube: Glass with magnifying lens and blue or red organic liquid.
      5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
      7. Stem: Aluminum.
8. Stem Length: To suit installation.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.02 THERMAL WELLS

A. Thermal wells:
   2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
   3. Material for Use with Copper Tubing: Copper nickel.
   5. Type: Stepped shank unless straight or tapered shank is indicated.
   6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
   7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
   8. Bore: Diameter required to match thermometer bulb or stem.
   9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.03 PRESSURE GAUGES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the work include, but are not limited to the following:
   1. Miljoco Corporation; miljoco.com
   2. Trerice Company; trerice.com
   3. Weiss Instruments; weissinstruments.com

B. Direct-Mounted, Metal-Case, Dial-Type Pressure Gauges:
   2. Case: Sealed type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
   3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
   5. Movement: Mechanical, with link to pressure element and connection to pointer.
   8. Window: Glass.
10. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.04 GAUGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass with NPS 1/4 ASME B1.20.1 pipe threads and porous-metal-type surge-dampening device. Include extension for use on insulated piping.

B. Valves: Tee or lever handle, Brass quarter-turn ball cock with NPS 1/4 ASME B1.20.1 pipe threads.
2.05 TEST PLUGS
   A. Description: Test-station fitting made for insertion into piping tee fitting.
   B. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.
   C. Thread Size: NPS 1/4 ASME B1.20.1 pipe thread.
   D. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.
   E. Core Inserts: EPDM self-sealing rubber.

2.06 TEST-PLUG KITS
   A. Furnish one test-plug kit containing two thermometers, one pressure gauge and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.
   B. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F.
   C. Pressure Gauge: Small, Bourdon-tube insertion type with 2- to 3-inch- diameter dial and probe. Dial range shall be at least 0 to 200 psig.
   D. Carrying Case: Metal or plastic, with formed instrument padding.

2.07 STATIC PRESSURE GAUGES
   A. Dial Gauges: Metal case, 3-1/2 inch diameter, diaphragm actuated, black figures on white background, front recalibration adjustment, with tubing and static pressure tips.
   B. Magnahelic Gauges: Cast aluminum housing and baked enamel finish suitable for indoor or outdoor installation. Provide optional signal flag for visual reference to maximum pressure drop.
   C. Accessories: Brass or copper static pressure tips with integral compression fittings, aluminum tubing, and vent valves.
   D. Static pressure gauges shall be calibrated in inches of water gauge and have ranges suitable for service intended.

PART 3 EXECUTION

3.01 INSTALLATION
   A. Install thermal wells with socket extending to center of pipe and in vertical position in piping tees.
   B. Install thermal wells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
   C. Install thermal wells with extension on insulated piping.
   D. Fill thermal wells with heat-transfer medium.
   E. Install direct-mounted thermometers in thermal wells and adjust vertical and tilted positions.
F. Install direct-mounted pressure gauges in piping tees with pressure gauge located on pipe at the most readable position.

G. Where installing one pressure gauge per pump, provide taps before strainers and on suction and discharge of pump. Connect NPS 1/4 inch piping to gauge.

H. Install valve and snubber in piping for each pressure gauge.

I. Install test plugs in piping tees.

3.02 ADJUSTING

A. After installation, calibrate meters according to manufacturers written instructions.

B. Adjust faces of meters and gauges to proper angle for best visibility.

3.03 THERMOMETER SCHEDULE

A. Install industrial-style, liquid-in-glass type thermometers in the following locations:
   1. Outlet of each domestic water heater, heat exchanger, and storage tank.
   2. Domestic hot water recirculating header from building.
   3. Header piping to central heating and chilled water equipment.
   4. Other locations detailed on Drawings.

B. Provide the following thermometer scale-ranges:
   1. Domestic Water Piping: 30 to 180 deg F.
   2. Heating Water Piping: 30 to 240 deg F.

3.04 PRESSURE GAUGE SCHEDULE

A. Install direct-mounted, dial-type pressure gauges in the following locations:
   1. Building water service entrance.
   2. Inlet to each expansion tank.
   3. Discharge of each pressure-reducing valve.
   4. Suction and discharge of each heating water pump.
   5. Suction and discharge of each chilled water pump.
   6. Other locations detailed on Drawings.

B. Provide the following pressure gauge scale-ranges:
   1. Domestic Water Piping: 0 to 100 psi.
   2. Heating Water Piping: 0 to 100 psi.

3.05 TEST PLUG SCHEDULE

A. Install test plugs with EPDM self-sealing rubber insert in the following locations:
   1. Inlet and outlet of each hydronic coil.
   2. Inlets and outlets of each heat exchanger.
   3. Other locations detailed on the Drawings.

3.06 STATIC PRESSURE GAUGE SCHEDULE

A. Install dial-type static pressure gauges in the following locations:
1. All air handler filter banks (included with air handlers).

END OF SECTION
SECTION 20 0529
HANGERS AND SUPPORTS

PART 1 GENERAL

1.01 SECTION INCLUDES
   A. Metal pipe hangers and supports.
   B. Trapeze pipe hangers.
   C. Metal framing systems.
   D. Thermal shield inserts.
   E. Fastener systems.
   F. Pipe stands.
   G. Equipment supports.

1.02 RELATED REQUIREMENTS
   A. Specifications throughout all divisions of the project manual are directly applicable to this section,
      and this section is directly applicable to them.

1.03 ACTION SUBMITTALS
   A. Product Data: Provide manufacturer’s catalog literature for each for each type of product
      indicated.
   B. Delegated-Design Submittal: For hangers, metal framing systems, pipe stands, and/or equipment
      supports indicated to comply with performance requirements and design criteria, including
      analysis data signed and sealed by the qualified professional engineer responsible for their
      preparation.
      1. Detail fabrication and assembly of hangers, systems, and supports.
      2. Calculate requirements for design and submit calculations.

1.04 COORDINATION
   A. Coordinate installation of hangers and supports with installation of piping, equipment, and
      ductwork.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS
   A. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand
      the effects of gravity loads and stresses within limits and under conditions indicated according to
      ASCE/SEI 7.
      1. Design supports for multiple pipes, including pipe stands, capable of supporting combined
         weight of supported systems, system contents, and test water.
      2. Design equipment supports capable of supporting combined operating weight of supported
         equipment and connected systems and components.
2.02 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.

2.03 TRAPEZE PIPE HANGERS

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

2.04 METAL FRAMING SYSTEMS

A. Description: Shop or field fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
   2. Channels: Minimum 12-gauge, 1-5/8-inch, continuous slotted steel channel with inturned lips and epoxy-coated finish.
   3. Channel Nuts: Formed or stamped steel nuts designed to fit into channel slot and, when tightened, prevent slipping along channel.
   5. Coupling: High-strength thermoplastic polypropylene insulation insert molded to fit clamp halves.

2.05 THERMAL SHIELD INSERTS

A. Insert Material: ASTM C533, Type I calcium silicate with 100-psig minimum compressive strength, ASTM C1136 ASJ vapor barrier jacket, and ASTM A527 galvanized steel shield.
   1. For Clevis or Band Hangers: Insert and shield shall cover lower half of pipe.
   2. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference.

B. Manufacturers:

2.06 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.
B. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated or stainless steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.07 PIPE POSITIONING SYSTEMS
A. Description: IAPMO PS 42, positioning system of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

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

2.09 MISCELLANEOUS MATERIALS
A. Structural Steel: ASTM A 36, carbon-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.
   2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 EXECUTION

3.01 HANGER AND SUPPORT INSTALLATION
A. Metal 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 the building structure.

B. Metal 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 for individual pipe hangers.
   2. Field fabricate from ASTM A 36, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

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 for use in lightweight concrete or concrete slabs less than 4 inches thick 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. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.
G. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

H. Install hangers and supports to allow controlled thermal 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, and at changes in direction of piping.

K. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

L. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

N. Insulated Piping:
   1. Attach clamps and spacers to piping.
      a. Use thermal-hanger shield insert with clamp sized to match outside diameter of insert.
      b. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
   2. Pipes 2-inch and Larger: Include reinforced calcium silicate insulation inserts of length at least as long as protective shield.
   3. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

O. Rigidly mounted domestic piping (where allowed) shall be secured to 12 gauge 1-5/8 inch slotted channel framing with insulated strut clamps.

P. Metal stud insulating pipe clamps shall be used to isolate piping away from steel stud framing.

3.02 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 bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.03 METAL FABRICATIONS

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

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap. Remove welding flux immediately.
3. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.04 ADJUSTING
A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.05 HANGER AND SUPPORT SCHEDULE
A. Specific hanger and support requirements are in sections specifying piping systems and equipment. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system sections.
B. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers, and metal framing systems and attachments for general service applications.
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 thermal-hanger shield inserts for insulated piping and tubing.
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 NPS 1/2 to NPS 30.
   2. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
   3. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
   4. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
   5. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
   6. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
   2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.
H. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system sections.
I. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system sections.
J. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION
SECTION 20 0553
PIPING AND EQUIPMENT IDENTIFICATION

PART 1 GENERAL

1.01 SECTION INCLUDES
   A. Equipment labels.
   B. Pipe and duct labels.
   C. Warning labels.
   D. Ceiling grid tags.

1.02 ACTION SUBMITTALS
   A. Product Data: Provide manufacturer's catalog literature for each for each type of product indicated.
   B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
   C. Valve Numbering Schedule: For each piping system to include in maintenance manuals.

1.03 QUALITY ASSURANCE
   A. Comply with ANSI A13.1 for lettering size, length, colors, and viewing angles of identification devices.

1.04 COORDINATION
   A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
   B. Coordinate installation of identifying devices with locations of access panels and doors.
   C. Install identifying devices before installing acoustic ceilings and similar concealment.

PART 2 PRODUCTS

2.01 MANUFACTURERS
   A. Subject to compliance with requirements, available manufacturers that may be incorporated into the work include, but are not limited to the following:
      3. Craftmark Pipe Markers; craftmarkid.com
      4. Graphic Products; graphicproducts.com
2.02 EQUIPMENT LABELS

A. Description: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
   1. Color: Black background with white lettering.
   2. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
   3. Minimum Label Size: Length and width vary for required label content, but not less than 3 by 1 inch.
   5. Fasteners: Stainless-steel rivets or self-tapping screws.
   6. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Contents: Include equipment's Drawing designation or unique equipment number.

C. Equipment Label Schedule: Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified.

2.03 PIPE AND DUCT LABELS

A. Description: Preprinted, color-coded, fade-resistant, vinyl material with lettering indicating service, and showing flow direction.
   1. Colors and Lettering Size: Comply with ANSI A13.1 for piping; White lettering on green background for air ducts.
   2. Flow-Direction Arrows: Integral with piping or duct system service lettering to accommodate both directions or as separate unit on each pipe or duct label to indicate flow direction.
   3. Adhesive: Contact-type, permanent-adhesive backing, compatible with carbon steel piping, plastic pipe, all service jackets, aluminum jacketing, and galvanized sheet steel.

B. Pipe Label Contents: Include identification of piping using same designations as used on Drawings and arrows indicating flow direction.

C. Duct Label Contents: Include identification of air service using same designations as used on Drawings and arrows indicating flow direction.

2.04 WARNING SIGNS AND LABELS

A. Description: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
   1. Color: Red background with white lettering.
   2. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
   3. Minimum Label Size: Length and width vary for required label content.
   5. Fasteners: Stainless-steel rivets or self-tapping screws.
   6. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Contents: Include caution and warning information plus emergency notification instructions.
2.05 CEILING GRID TAGS

A. Description: Vinyl self-adhesive labels, for installation on ceiling grid for equipment located above lay-in ceiling.
   1. Color: Black lettering on a white background.
   2. Size: 3/4-inch wide by 3-mil thick, variable length.

B. Label Contents: Include equipment's drawing designation or unique equipment number.

PART 3 EXECUTION

3.01 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, and paints.

3.02 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.03 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment using fasteners or adhesive.

B. Identify control panels, major control components, fire dampers and smoke dampers.

C. Locate equipment labels where accessible and visible.

3.04 PIPE LABEL INSTALLATION

A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; mechanical 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 25 feet along each run. Reduce intervals in areas of congested piping and equipment.

3.05 DUCT LABEL INSTALLATION

A. Locate duct labels in mechanical rooms near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling systems.
3.06 CEILING TAG INSTALLATION

A. Affix ceiling grid tags to locate valves, dampers, control devices, and other concealed equipment above panel type ceilings. Locate in corner of grid closest to equipment/device.

END OF SECTION
PART 1 GENERAL

1.01 SECTION INCLUDES

A. Balancing Air Systems:
   1. Variable-air-volume systems.

B. Balancing Hydronic Piping Systems:
   1. Variable-flow hydronic systems.

C. Testing, Adjusting, and Balancing Equipment:
   1. Motors.
   2. Heat-transfer coils.

1.02 RELATED REQUIREMENTS

A. Specifications throughout all divisions of the project manual are directly applicable to this section, and this section is directly applicable to them.

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this project, unless identified by a specific edition date. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this project.

B. Associated Air Balance Council:
   1. AABC MN-1 - AABC National Standards for Total System Balance.

C. American Society of Heating, Refrigerating and Air-Conditioning Engineers:

D. National Environmental Balancing Bureau:
   1. NEBB (TAB) - Procedural Standards for Testing Adjusting Balancing of Environmental Systems.

E. Sheet Metal and Air Conditioning Contractors' National Association:
   1. SMACNA (TAB) - HVAC Systems Testing, Adjusting, and Balancing.

1.04 ACTION SUBMITTALS

A. Qualification Data: Submit documentation that the testing and balancing agency and field specialists meet the qualifications specified in the quality assurance article.

B. Strategies and Procedures Plan: At least 6-weeks prior to the start of testing, adjusting, or balancing activities, submit strategies and step-by-step procedures as specified in the preparations article.
1.05 INFORMATIONAL SUBMITTALS

A. Control System Coordination Reports: Communicate in writing to the controls installer all setpoint and parameter changes made or problems and discrepancies identified during TAB that affect, or could affect, the control system setup and operation.

B. Instrument Calibration Reports: To include instrument type and make, serial number, application, dates of use, and dates of calibration.

C. Field Deficiency Reports: Include defects and deficiencies that will or could prevent proper testing and balancing. Beginning or continuing with the work indicates acceptance of examined conditions.

1.06 CLOSEOUT SUBMITTALS

A. Final Report: Prepare a certified written report to meet the requirements specified in the final report article at the end of this section. Tabulate and divide the report into separate sections for tested systems and balanced systems.

B. A final successful test and balance report shall be submitted to the engineer, with adequate time for thorough review, prior to the substantial completion visit.

1.07 QUALITY ASSURANCE

A. TAB Agency Qualifications:
   1. An independent company specializing in the measurement, testing, adjusting, and balancing of plumbing and mechanical systems, not affiliated with any other contractor or equipment supplier on the project.
   2. Having a minimum of 5-years documented experience with installations of similar size and complexity. Submit a list including reference contacts.
   3. Certified by one of the following:
   4. TAB Field Supervisor and Technician: Employee of the TAB agency and certified by the same organization.

B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

PART 2 PRODUCTS (NOT APPLICABLE)

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

A. Perform total system balance in accordance with one of the following:
   1. AABC National Standards for Total System Balance.
   4. Maintain at least one copy of the standard to be used at project site at all times.
B. Begin work after completion of systems to be tested, adjusted, or balanced, and complete work prior to the date of substantial completion of the project, phases or sub-phases.

C. Where hvac systems and/or components interface with life safety systems, including fire and smoke detection, alarm, and control, coordinate scheduling, testing, and inspection procedures with the authorities having jurisdiction.

D. BAS Coordination:
   1. In addition to the settings specified herein, collaborate with the BAS contractor any settings that will be determined by the TAB Agency. Settings may include but are not limited to: flow coefficients, airflow conditions, damper positions, static and differential pressure setpoints, variable speed drives, etc.
   2. The TAB Agency's equipment shall include a PC for interface to the BAS. Utilize operator interface software and any special hardware (cables, signal converters) provided to allow for the PC to interface to the BAS.
   3. The TAB Agency shall engage with the BAS contractor for adequate training so that they can utilize the operator interface without ongoing assistance from the BAS contractor.

E. Minimum Fan Speed:
   1. The minimum fan speed setting within each variable speed drive itself shall be optimized in the field to be as low as possible while avoiding inertial stalling.
   2. The minimum pump speed setting within each variable speed drive itself shall be no less than 30% to protect the seal from premature failure.

F. Flow Verification: This contractor shall review the drawings and coordinate with the heating and/or plumbing contractor and the controls contractor to confirm that a means of flow verification is provided at each coil circuit and/or other indicated locations.
   1. Verify by measuring differential pressure across the flow control valve or the pressure independent control valve, and comparing to manufacturer’s published flow charts.
   2. Where no means is provided, instruct the mechanical contractor to install a venturi valve on the supply side of the coil, and verify flow as indicated above.

3.02 TOLERANCES

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

B. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design to the space. Adjust outlets and inlets in the space to within plus or minus 10 percent of design.

C. Hydronic Systems: Adjust heating and/or cooling water flow rates to within plus or minus 10 percent of design.

D. Maintaining design pressure relationships shall have priority over the tolerances specified above.

3.03 EXAMINATION

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

B. Examine installed systems for balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these devices are applicable for intended purpose and are accessible.
C. Examine ceiling air plenums used for return or relief air, to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

D. Examine approved equipment submittal performance data including fan curves and pump curves. Relate performance data to project conditions and requirements, to evaluate undesired or unpredicted conditions that may cause reduced capacities in all or part of a system.

E. Examine system and equipment installations and verify that field quality control testing, cleaning, and adjusting specified in individual sections have been performed.

F. Examine equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

G. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

H. Examine strainers and verify that permanent screens with indicated perforations have replaced startup screens.

I. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.

J. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

K. Examine system pumps to ensure absence of entrained air in the suction piping.

L. Examine operating safety interlocks and controls on HVAC equipment.

M. Examine test reports specified in individual system and equipment sections.

3.04 PREPARATION

A. Prepare a strategies and procedures plan that includes the following:
   1. Equipment and systems to be tested.
   3. Sample forms with specific identification for all equipment.
   4. Instrumentation to be used.

B. Perform checks of systems and equipment to verify system readiness for testing and balancing work. At a minimum, include the following:
   1. Airside:
      a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
      b. Duct systems are complete with terminals installed.
      c. Volume, smoke, and fire dampers are open and functional.
      d. Fans are operating, free of vibration, and rotating in correct direction.
      e. Variable-frequency controller startup is complete and safeties are verified.
      f. Automatic temperature control systems are operational.
      g. Suitable access to balancing devices and equipment is provided.
      h. Clean filters are installed.
   2. Hydronics:
      a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
b. Piping is complete with all coils connected and terminals installed.
c. Systems are flushed, filled, and air purged. Water treatment is complete.
d. Control valves are functioning per the sequence of operation.
e. Shutoff and balance valves are verified to be 100-percent open.
f. Pumps are started and proper rotation is verified.
g. Pump gauge connections are installed at inlet and outlet flanges.
h. Test ports are installed at inlet and outlet piping to coils, valves, and/or strainers.
i. Variable-frequency controller startup is complete and safeties are verified.
j. Suitable access to balancing devices and equipment is provided.
k. Strainers are pulled and cleaned.

3.05 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system in accordance with one of the following:
   1. AABC National Standards for Total System Balance.
   4. Maintain at least one copy of the standard to be used at the project site at all times.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for the TAB procedures.
   1. After testing and balancing, patch probe holes in ducts with the same material and thickness as used to construct the ducts.
   2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to applicable specifications.

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. Measure and report testing and balancing measurements in inch-pound (IP) units only.

3.06 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Measure and adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.

C. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.

D. For variable-air-volume systems, develop a plan to simulate diversity. Full flow in one section of the system may be simulated by temporary restriction of flow to other sections.

E. Determine the best locations in main and branch ducts for accurate airflow measurements.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.
I. Check ductwork and equipment for airflow blockages.
J. Check condensate drains for proper connections and function.
K. Check air-handling-unit components for proper seals.

3.07 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:
   1. Measure fan static pressures as follows:
      a. Measure static pressure directly at the fan outlet or through the flexible connection.
      b. Measure static pressure directly at the fan inlet or through the flexible connection.
      c. Measure static pressure across each component that makes up the air-handling system.
      d. Report any artificial loading of filters at the time static pressures are measured.
   2. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
      a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
      b. Verify that terminal units are meeting design airflow under system maximum flow.
   3. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.
   4. Verify final system conditions as follows:
      a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
      b. Re-measure and confirm that total airflow is within design.
      c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
      d. Test system in economizer mode. Verify proper operation and adjust if necessary.
      e. Measure and record all operating data.
      f. Record final fan-performance data.
      g. Mark all final settings.

3.08 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and manufacturer recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.

B. Where flow-metering devices are not installed, base flow balance on pressure drop or temperature difference across various heat transfer elements in the system. Do not use service or shut-off valves for balancing.

C. For variable-flow systems, develop a plan to simulate diversity. Full flow in one part of the system may be simulated by temporary restriction of flow to other parts.

D. For primary-secondary hydronic systems, balance the primary circuit flow first, then the secondary circuits.

E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

F. Verify that motor starters are equipped with properly sized thermal protection.
G. Check liquid level in the expansion tank.
H. Check highest vent for adequate pressure.
I. Check flow-control valves for proper position.
J. Check that air has been purged from the system.
K. Procedures for Balancing Valves:
   1. The balancing procedure starts at the terminal units. The terminals are balanced against
      themselves before any attempt is made at the branches.
   2. After all terminals from all branches are balanced against themselves, the branches are
      balanced against themselves.
   3. Finally, the risers are balanced against themselves and the total flow rate and the pump
      head may be checked.
   4. Where applicable, the pump head is then set to an optimum value (variable speed pumps).

3.09 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, rpm, phase and hertz.
   3. Nameplate and measured voltage, each phase.
   4. Nameplate and measured amperage, each phase.
   5. Starter size and thermal-protection-element rating.
   6. Service factor and frame size.

3.10 PROCEDURES FOR HEAT TRANSFER COILS
A. Measure, adjust, and record the following data for each water coil:
   1. Airflow.
   2. Water flow rate.
   3. Entering and leaving water temperature.
   4. Water pressure drop for air handler coils.
   5. Dry-bulb temperature of entering and leaving air.
   6. Wet-bulb temperature of entering and leaving air for cooling coils.
B. Measure, adjust, and record the following data for each electric heating coil:
   1. Airflow.
   2. Entering and leaving air temperature at full load.
   3. Voltage and amperage input of each phase at full load.
   4. Fuse or circuit breaker rating for overload protection.
   5. Calculated kilowatt at full load.
   6. Nameplate data.
C. Measure, adjust, and record the following data for each refrigerant coil:
   1. Airflow.
   2. Dry-bulb temperature of entering and leaving air.
   3. Wet-bulb temperature of entering and leaving air.
3.11 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.
   3. Certify validity and accuracy of field data.

B. Report Contents: In addition to certified field-report data, include the following:
   1. Manufacturers test data.
   2. Pump curves and fan curves.
   3. Field test reports prepared by system and equipment installers.
   4. Other information relative to equipment performance, excluding shop drawings and product data.

C. Report Data: In addition to form titles and entries, include the following data:
   1. Title page with project name, address, and altitude, name and contact information of the TAB agency, project engineer and contractors list, and the report date.
   2. Signature of the TAB supervisor who certifies and is responsible for the report.
   3. Table of Contents with pages defined for each section of the report.
   4. Nomenclature sheets for each item of equipment.
   5. Data for terminal units, including manufacturer's name, type, size, and fittings.
   6. Notes to explain why certain final data in the body of reports vary from indicated values.
   7. Test conditions for fans and pump performance forms including the following:
      a. Conditions of filters.
      b. Cooling coil, wet and dry bulb conditions.
      c. Face and bypass damper settings at coils.
      d. Fan drive settings including settings and percentage of maximum pitch diameter.
      e. Settings for outdoor, return, and exhaust air dampers.
      f. Settings for supply air, static-pressure controller.
      g. 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. Quantities of outdoor, supply, return, and exhaust airflows.
   2. Hydronic heating and cooling water flow rates.
   3. Duct, outlet, and inlet sizes.
   4. Pipe and valve sizes and locations.
   5. Terminal units.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following (where applicable):
   1. Unit Data:
      a. Unit identification.
      b. Location.
      c. Make and type.
      d. Model number and unit size.
e. Manufacturer’s serial number.
f. Unit arrangement and class.
g. Discharge arrangement.
h. Sheave make, size in inches, and bore.
i. Center-to-center dimensions of sheave and amount of adjustments in inches.
j. Number, make, and size of belts.
k. Number, type, and size of filters.

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

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

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

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

G. Fan Test Reports: For supply, return, and exhaust fans, include the following:
   1. Fan Data:
      a. System identification.
      b. Location.
      c. Make and type.
      d. Model number and size.
      e. Manufacturer's serial number.
      f. Arrangement and class.
      g. Sheave make, size in inches, and bore.
      h. Center-to-center dimensions of sheave and amount of adjustments in inches.

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

   3. Test Data (Indicated and Actual Values):
      a. Total airflow rate in cfm.
      b. Total system static pressure in inches wg.
      c. Fan speed in rpm.
      d. Discharge static pressure in inches wg.
      e. Suction static pressure in inches wg.

H. Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
   1. Report Data:
      a. System and air-handling-unit number.
      b. Location and zone.
      c. Traverse air temperature in deg F.
      d. Duct static pressure in inches wg.
      e. Duct size in inches.
      f. Duct area in square feet.
      g. Indicated airflow rate in cfm.
      h. Indicated velocity in fpm.
      i. Actual airflow rate in cfm.
      j. Actual average velocity in fpm.
      k. Barometric pressure in psig.

I. Air-Terminal-Device Reports:
1. Unit Data:
   a. System and air-handling unit identification.
   b. Location and zone served.
   c. Apparatus used for test.
   d. Number from system diagram.
   e. Make, type, size, and model number.
   f. Effective area in square feet.

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

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

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

K. Instrument Calibration Reports:
1. Report Data:
   a. Instrument type and make.
   b. Serial number.
   c. Application.
   d. Dates of use.
   e. Dates of calibration.

3.12 VERIFICATION OF TAB REPORT

A. The Owner, engineer, construction manager, or commissioning authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

B. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
C. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

D. If TAB work fails, proceed as follows:
   1. The TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
   2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.

END OF SECTION
SECTION 21 1300
FIRE-SUPPRESSION SPRINKLER SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES
A. Wet-pipe sprinkler system.
B. System design, installation, and certification.

1.02 REFERENCE STANDARDS
B. NFPA 13 - Standard for the Installation of Sprinkler Systems; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
D. UL (DIR) - Online Certifications Directory; current listings at database.ul.com.
E. UL 405 - Fire Department Connection Devices; Current Edition; Including All Revisions.

1.03 SUBMITTALS
A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
B. Product Data: Provide data on sprinklers, valves, and specialties, including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.
C. Shop Drawings:
   1. Indicate hydraulic calculations, detailed pipe layout, hangers and supports, sprinklers, components and accessories. Indicate system controls.
   2. Submit shop drawings to Authorities Having Jurisdiction for approval. Submit proof of approval to Architect.
D. Operation and Maintenance Data: Include components of system, servicing requirements, record drawings, inspection data, replacement part numbers and availability, and location and numbers of service depot.
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 Sprinklers: Type and size matching those installed, in quantity required by referenced NFPA design and installation standard.
   3. Sprinkler Wrenches: For each sprinkler type.

1.04 QUALITY ASSURANCE
A. Comply with FM (AG) requirements.
B. Designer Qualifications: Design system under direct supervision of a Professional Fire Protection Engineer experienced in design of this type of work and licensed in the State in which the Project is located.
PART 2 PRODUCTS

2.01 SPRINKLER SYSTEM
A. Sprinkler System: Provide coverage for entire building.
B. Occupancy: Light hazard; comply with NFPA 13.
C. Water Supply: Determine volume and pressure from water flow test data.
D. Interface system with building control system.
E. Storage Cabinet for Spare Sprinklers and Tools: Steel, located adjacent to alarm valve.

2.02 SPRINKLERS
A. Suspended Ceiling Type: Semi-recessed pendant type with matching push on escutcheon plate.
   1. Response Type: Quick.
   2. Coverage Type: Standard.
   3. Fusible Link: Fusible solder link type temperature rated for specific area hazard.
B. Exposed Area Type: Pendant type with guard.
   1. Response Type: Quick.
   2. Coverage Type: Standard.
   3. Fusible Link: Fusible solder link type temperature rated for specific area hazard.
C. Sidewall Type: Semi-recessed horizontal sidewall type with matching push on escutcheon plate.
   1. Response Type: Quick.
   2. Coverage Type: Standard.
   3. Fusible Link: Fusible solder link type temperature rated for specific area hazard.
D. Residential Sprinklers: Concealed upright type with matching push on escutcheon plate.
   1. Response Type: Quick.
   2. Fusible Link: Fusible solder link type temperature rated for specific area hazard.
E. Storage Sprinklers: Pendant type with guard.
   1. Response Type: Standard.
   2. Coverage Type: Standard.
   3. Fusible Link: Fusible solder link type temperature rated for specific area hazard.
F. Guards: Finish to match sprinkler finish.

2.03 PIPING SPECIALTIES
A. Wet Pipe Sprinkler Alarm Valve: Check type valve with divided seat ring, rubber faced clapper to automatically actuate water motor alarm, pressure retard chamber and variable pressure trim with the following additional capabilities and features:
B. Backflow Preventer: Reduced pressure principle valve assembly backflow preventer with drain and OS & Y gate valve on each end.
PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with referenced NFPA design and installation standard.

B. Install equipment in accordance with manufacturer’s instructions.

C. Place pipe runs to minimize obstruction to other work.

D. Place piping in concealed spaces above finished ceilings.

E. Apply masking tape or paper cover to ensure concealed sprinklers, cover plates, and sprinkler escutcheons do not receive field paint finish. Remove after painting. Replace painted sprinklers.

F. Flush entire piping system of foreign matter.

G. Install guards on sprinklers where indicated.

H. Hydrostatically test entire system.

I. Require test be witnessed by Fire Marshal.

END OF SECTION
PART 1 GENERAL

1.01 SCOPE

A. Furnish and install an automatic sprinkler system to the CNCIA Holdroom of the Natrona Country Airport as indicated herein and as shown on the drawings. Connect system to a water supply of sufficient pressure to ensure full and sustained water discharge from sprinkler heads when opened by fire at rated heat temperatures. Water supply shall conform to NFPA water supply requirements with considerations given to the reliability of the public water supply, taking into account probable minimum pressure conditions. System is supplied from a new fire service line connection to the water system. The new system will back feed the existing fire sprinkler system as indicated on the drawings. The water supply system capacities are as follows as provided by the City of Casper: 58 PSI Static, 26 PSI Residual with 2,295 GPM flowing.

B. All portions of the systems shall be installed in accordance with the drawings, details, and specifications and as required by jurisdictional authorities and codes. The position is taken that the Owner is entitled to a project which meets or exceeds the minimum requirements of nationally recognized fire protection standards. All efforts and installations shall be directed toward this end. Where there is conflict between the contract drawings and/or specifications, and the requirements of the jurisdictional authorities or codes, the conflict shall be brought to the attention of the Engineer at least ten (10) days prior to bidding or be resolved at no cost to the Owner. If the contractor has not identified conflicts to the Engineer, he shall be responsible for complying with the most restrictive (expensive) methods.

C. The intent of these specifications is to describe the complete systems to be installed, including minor details of work or materials not specifically mentioned or shown on the drawings, but necessary for the successful operation and completion of the installation.

D. All piping to be concealed above ceilings. Areas with gyp-board or hard lid ceilings will need be cut, patched and painted as necessary for piping installation. See Architectural plans for ceiling types and locations.

E. Areas where mechanical mezzanines are located have limited ceiling space between the mechanical mezzanine and the ceiling below. Pipe routing below mechanical mezzanines should be minimized or limited only to supply sprinklers located within that space.

F. New fire sprinkler riser equipment, including backflow preventer, shall be located in the water entrance room as indicated on the drawings.

G. The fire department connection and vertical piping shall be routed on the exterior of the building and attached to the exterior building wall as indicated on the drawings. Automatic ball drip shall be installed at the bottom of the piping at the exterior.

H. Work to be performed under this section shall include, but not be limited to the following:

1. Automatic fire sprinkler systems.
   a. Wet Pipe System.
      1) Pipe and fittings.
      2) Hangers and supports.
      3) Earthquake bracing.
4) Valves.
5) Alarms.
6) Flow and Tamper Switches.
7) Specialties.

I. Furnish and install an automatic fire protection system of type or types required in the following areas:
   1. All areas of the Natrona County Airport building as detailed in architectural phasing: Wet Pipe system.

1.02 RELATED WORK
   A. All work performed under this section of the specifications shall be subject to the requirements of both the General and Special Conditions.

1.03 REGULATORY AGENCIES
   A. The term jurisdictional authority (or Authority Having Jurisdiction) used in this section of the specification shall include, as applicable, but not be limited to the following:
      1. Casper Building Department.
      3. Casper Fire Chief
      4. Insurance Services Office or Insuring Authority having jurisdiction.
      5. Owner.
   B. The design and installation of all systems of fire protection shall conform to all requirements of applicable codes and publications herein defined:
      3. NFPA#13 (2013)
      4. City of Casper Fire Department
      5. All State and local ordinances
      6. Underwriters' Laboratories
      7. American Society of Testing Materials
      8. American National Standards Institute
      9. Occupational Safety and Health Administration

1.04 SUBMITTALS
   A. General
      1. The successful Contractor shall provide submittal data as required under other portions of this specification. Submittals shall conform to the instructions set forth in the General and Special Conditions of these specifications entitled Shop Drawings and Submittals.
      2. The Contractor shall be responsible for submitting the fire sprinkler system shop drawings, calculations and product data to the Authority Having Jurisdiction for approval.
3. Work on the project shall not begin until submittals have been accepted by the Engineer and the Authority Having Jurisdiction.

B. Shop Drawings

1. Submit shop drawings (floor plans - detailed working drawings), showing dimensions, ducts, lights, or other items affecting the fire protection systems shall be submitted to jurisdictional agencies for review and approval. All items identified in NFPA #13 for proper working drawings shall be complied with. Concurrently, they shall be sent to the Engineer for review. The Engineer will reject all submittals not in compliance. After approvals from jurisdictional agencies have been returned to the Contractor, they shall be submitted to the Engineer for final acceptance. These final acceptance sets shall have all agencies’ stamps of review and acceptance.

2. Shop drawings shall be prepared in AutoCAD or compatible software.

3. The shop drawings shall be signed and sealed by the Professional Engineer responsible for their preparation.

4. Engineer’s review will be for general location and compliance with design intent only. It will be the Contractor’s responsibility to check his drawings for interferences and to do shop fabrication from measurements taken at the job site.

C. Catalog/Product Information

1. Full catalog information shall be submitted for approval for all materials intended for use on this project. Catalog information indicating more than one item shall be highlighted to clearly indicate the proposed equipment.

D. Hydraulic Calculations

E. Hydraulic calculations shall be submitted for approval. Calculations shall be provided to substantiate the pipe sizes shown on shop drawings. Should the Engineer question the pipe size for any area, the Contractor shall provide additional calculations to the satisfaction of the engineer. The hydraulic calculations shall be signed and sealed by the Professional Engineer responsible for their preparation.

F. Installer’s Qualifications

1. All systems of fire protection shall be installed by a licensed (for the location of installation) Fire Protection Contractor, fully experienced in fire protection installation as required and specified herein.

2. Fire Protection Contractors may be required to provide in writing specific information as to successfully completed projects and references to show cause as to why they should be considered acceptable to the engineer.

G. Close-Out

1. Record Drawings required per paragraph 1.6 and Operation and Maintenance Manuals required per paragraph 1.7, shall be submitted for approval.

1.05 JOB CONDITIONS

A. The Contractor shall investigate both existing and new structural, mechanical, electrical, and finished conditions affecting the piping, and shall arrange the equipment accordingly; furnishing required fittings, offsets and accessories. Route fire protection piping to avoid interference with structure, ceilings, lighting, duct work, and drain piping. In the event it becomes necessary to make field changes in pipe locations due to building construction, the Contractor shall consult
with the Engineer responsible for the design before making any changes. Any such changes required shall be made without added cost to the Owner.

B. The Contractor shall determine, and be responsible for, the proper locations and type of inserts for hangers, chases, sleeves, and other openings in the construction required for fire protection work, and shall obtain this information well in advance of the construction progress to avoid delay of the work.

C. Contractor is responsible for final locations of sprinkler heads and routing of piping. Contractor shall review all contract documents including architectural, structural, mechanical, electrical, etc. for actual contract conditions.

D. All fees and permits specifically required for fire protection work, not obtained by others as specified elsewhere shall be applied for and paid for by this Contractor.

1.06 RECORD DRAWINGS

A. One approved set of drawings shall be maintained on the job at all times.

B. One set of "As-Built" drawings shall be kept on the job at all times. "As-Built" drawings shall be kept current daily. "As-Built" drawings shall be available at all times to Engineer for review and use.

C. One reproducible set of “As-Built” drawings shall be provided to the Engineer upon completion of the work.

1.07 OPERATION AND MAINTENANCE MANUALS

A. Three (3) sets of operating and maintenance instructions shall be provided the Owner upon completion. Manuals shall include, as a minimum, the following:
   1. “As-Built” Drawings
   2. Catalog cut sheets of all materials installed
   3. Equipment maintenance manuals
   4. Hydraulic Calculations
   5. Acceptance Test Certificate
   6. Certification of Owner Training
   7. Contractor Guarantee and Warranty
   8. “As-Built” AutoCAD drawing (.dwg) file or equal of “As-Built” drawings on CD

B. One (1) original copy of NFPA #25 (2013) shall be provided to the Owner with the Operation and Maintenance Manuals.

1.08 TRAINING

A. The Fire Protection Contractor shall instruct the Owner in the operation of the systems. Instruction shall continue until the Owner is fully satisfied that he understands the operation of his system.

B. Contractor shall obtain Owner’s dated signature that all training has been accomplished and is acceptable to the Owner.

1.09 GUARANTEES AND WARRANTIES
A. The Fire Protection Contractor shall guarantee to the Owner in writing, all equipment and workmanship for a period of one (1) year after the fire protection system has been placed in continuous service and has been accepted by all authorities having jurisdiction.

B. The Fire Protection Contractor shall not be held responsible for improper or negligent maintenance by the Owner after operating and maintenance indoctrination has been given the Owner.

PART 2– PRODUCTS

4.01 AUTOMATIC SPRINKLERS

A. Install sprinklers from reviewed shop drawings.

B. All sprinklers shall be of similar design and from a single manufacturer.

C. The operating temperature of sprinklers shall be as required by the specific location of installation.

D. Sprinklers shall conform to the following schedule:

1. Brass upright or pendent may be used in all attic, mechanical, storage or other non-public spaces; or in areas where piping and sprinklers are installed exposed.

2. White recessed dry pendent sprinklers shall be used in all finished areas, offices, classrooms, corridors, etc. Where surface mounted obstructions will not allow for recessed installation, two-piece escutcheons may be used to extend sprinklers to a maximum deflector distance as allowed by NFPA or U.L. listing. Two piece escutcheons may be used where specifically indicated or where head guards are required.

3. White recessed dry sidewall sprinklers may be used in accordance with listing and jurisdictional requirements.

4. All sprinklers shall be quick-response glass bulb type.

E. Manufacturers

1. Tyco
2. Victaulic
3. Viking
4. Reliable

4.02 PIPE AND FITTINGS

A. Interior piping for automatic sprinkler system shall conform to NFPA #13 and as follows.

B. Sprinkler piping above ground with threaded fittings may be Schedule 40, Dyna Thread or equal black steel pipe with a corrosion resistance rating equal to or greater than 1.0. Threaded thinwall pipe with a CRR less than 1.0 shall not be used.

C. Fittings for threaded and coupled pipe shall consist of cast iron, malleable iron or ductile iron threaded fittings joined with Teflon tape thread sealing compound or pipe joint compound. Pressure rating of fittings shall be as required for application.

D. Sprinkler piping above ground with grooved fittings for sizes 2½” and larger may be Schedule 10, Dyna Flow or equal black steel pipe.
E. CPVC piping and fittings may be used when installed in accordance with NFPA #13 requirements and the listing requirements from the manufacturer.

F. Flexible piping drops shall be used to connect piping to sprinklers located in suspended acoustical tile ceilings. Flexible piping drop assemblies shall have stainless steel braided hose coverings.

G. Fittings for plain end pipe shall not be used.

H. All drain and fire department connection piping and fittings down-stream of valves shall be galvanized. Painted grooved fittings are acceptable.

4.03 HANGERS AND SUPPORTS

A. Space pipe hangers in accord with the requirements of NFPA #13. Construct hangers, hanger rods, inserts and clamps as approved by the same.

B. Manufacturers:
   1. Tolco
   2. Afcon
   3. Erico
   4. Speedy Product (Super Screws)
   5. Elco (Hanger Mate)

4.04 EARTHquake PROTECTION

A. Furnish and install all earthquake bracing and restraint as required by International Building Code, NFPA #13 and the authority having jurisdiction.

B. Contractor to coordinate bracing attachment to wood structure with structural drawings for any additional bracing or stiffening of structure that may be necessary.

C. Concrete insert attachments used for seismic bracing shall be approved for use in Seismic Design category C or D.

D. Provide flexible couplings and clearance at pipe penetrations as required by NFPA #13.

E. Manufacturers:
   1. Cooper B-Line (Tolco)
   2. Afcon
   3. Erico

4.05 VALVES

A. Gate valves shall be approved indicating type as required by NFPA #13. Check valves shall be as required by NFPA #13. Test and drain valves shall be approved brass globe or angle valves. Locate sprinkler system isolation valves as shown on the drawings complete with a tamper alarm.

B. Interior
   1. Gate
      Make: Nibco
      Sizes: 2½" through 6"
      Ends: Flanged
      Model: F-607-OTS
2. Butterfly
   Make: Tyco
   Sizes: 2½“ through 6”
   Ends: Grooved
   Model: BFV-N
   Note: Butterfly valves may be used in lieu of OS&Y valves at the Contractor's option for 2½“ and larger valves.

3. Check Valve
   Make: Tyco
   Sizes: 2½“ through 6”
   Ends: Grooved
   Model: CV-1F

4. Drain Valve
   Make: United Brass
   Sizes: ½“ through 2”
   Ends: Threaded
   Model: Model 125SUL and Model 126SUL

5. Test and Drain Valve
   Make: AGF
   Sizes: 1“ through 2”
   Ends: Threaded
   Model: 1011, 1000, and 1011T

C. Manufacturers:
   1. Nibco
   2. United Brass
   3. Tyco
   4. Victaulic
   5. Reliable
   6. AGF

4.06 BACKFLOW PREVENTION DEVICES
   A. Install new backflow prevention devices as required by the Water Authority having jurisdiction.
   B. Devices shall be UL or FM approved.
   C. All reduced pressure backflow prevention devices shall be provided with an air gap drain with splash guard and piped to the exterior with galvanized pipe and fittings.
   D. Manufacturers:
      1. Febco
      2. Ames
3. Watts

4.07 FIRE DEPARTMENT CONNECTIONS

A. Furnish and install where approved by the authority having jurisdiction a fire department connection.

B. Fire department connections shall be set at existing height. Finish shall be rough brass.

C. Fire department connections for sprinkler system shall be indexed "auto spkr". The indexing shall be "cast in" by the manufacturer. Required indexing shall be permanently installed directly above the connection.

D. Fire department connection shall be complete with plug and chain and shall have threads to meet the local fire department requirements. Provide an automatic ball-drip drain at the low point of piping subject to freezing between the fire department connection and the check valve.

E. Manufacturers:
   1. Potter Roemer
   2. Croker
   3. Tyco
   4. Powhatan

4.08 SPECIALTIES

A. Fire Seals
   1. Where piping passes through walls, floors or other building construction which by code requires a fire rating, approved fire rated assemblies shall be used. Proposed protection shall be submitted for approval. Plans shall clearly indicate details and locations of required protection.

B. Escutcheon Plates
   1. Where exposed piping passes through finish work, chrome plated (or other finish acceptable to the Architect) wall plates shall be installed. Split wall plates or escutcheons shall be installed to fit snugly around piping. All wall plates shall be metal.
   2. Solid galvanized wall plates shall be used at both sides of all exterior walls.

C. Valve Identification
   1. All valves within the building shall have permanently marked identification signs provided in accordance with NFPA #13 standards. Signs shall be manufactured and not hand written. Signs shall be hung with galvanized or chrome chain.

D. Spare Head Supply
   1. Furnish and install a supply of extra sprinklers of each type and degree link installed in the project, complete with mountable box. Mount box on wall next to sprinkler riser. Provide Spare Head Supply

E. Sprinkler Head Guards.
   1. Provide head guards on any sprinklers installed within seven feet of the finished floor.

4.09 ELECTRICAL DEVICES
A. All electrical devices shall be coordinated with Electrical (Division 26) and Intelligent Reporting Fire Alarm System (Section 28 31 20) requirements for compatibility of voltages and manufacturer.

B. Pressure Switch
   1. Potter PS10-2

C. Tamper Switch
   1. Potter OSYSU-2
   2. Potter PCVS
   3. Potter RBVS

D. Audio/Visual Alarm Indicating Appliances
   1. Audio/Visual units shall provide a common enclosure for the fire alarm audible and visual alarm devices. The housing shall be designed to accommodate either horns, bells, or chimes. The unit shall be complete with a tamper resistant, Pyramidal shaped lens with “Fire” lettering visible from a 180° field of view. Integral Xenon strobe shall provide a minimum light output of 75 candela at 24VDC at a minimum 45 flashes per minute rate. Xenon strobes shall provide a 4-wire connection to insure properly supervised in/out system connection. Unit shall be complete with all mounting hardware including backbox.

E. Manufacturers:
   1. Potter
   2. System Sensor

PART 3– EXECUTION

5.01 DESIGN CRITERIA

A. The entire sprinkler system is not shown on plans. The intent is for the contractor to provide a complete sprinkler system as required. This Contractor shall be responsible for surveying the site, existing construction, and new construction, and prepare working drawings for the total system.

B. The fire protection system supplier shall design the piping to supply the system. Piping shall be laid out so as not to interfere with the installation of other piping, ductwork or light fixtures.

C. Piping layout shall not interfere with maintenance clearance requirements for mechanical or electrical equipment. Maintain 36” clearance as necessary for mechanical and electrical equipment. This includes equipment above ceilings (VAV boxes, electric heating coils, fan boxes, etc.).

D. All piping shall be run concealed wherever possible. Where piping is run exposed, special notation on Contractor’s shop drawings to that effect shall be evident and conspicuous. Any piping determined to be a problem shall be relocated at no cost to the Owner.

E. Pipe shall not be routed through or above vestibule ceilings wherever possible. Vestibules shall be protected with dry sidewall sprinklers or dry pendent sprinklers from piping above where necessary.

F. System piping to be hydraulically calculated in accordance with NFPA #13 to the point of connection verified for flow characteristics.
G. The preparation of all shop drawings and hydraulic calculations are the responsibility of the installing Contractor and shall be accomplished and stamped by a Registered Professional Engineer, competent in fire protection.

5.02 INSTALLATION

A. Where details of installation are not given, the installation shall be made using manufacturer's recommended practices or at the direction of the Engineer.

B. Contractor shall complete the fire protection systems ready for operation, in all respects, as soon as possible. When system is complete and ready for continuous operation, activate the system for its intended use. After system has been activated for continuous use, water charges will be paid by the Owner.

C. This Contractor shall remove from the building, all rubbish and unused materials due to or connected with this installation.

D. The surface of all piping shall be cleaned and left ready for painting. This includes the removal of any tags or stickers from the piping.

5.03 TESTING

A. All testing shall be accomplished in accord with NFPA standards and requirements.

B. This Contractor shall call for inspection and complete Contractor’s Material and Test Certificates signed by the Authority Having Jurisdiction.

C. The entire sprinkler system shall be hydrostatically tested at not less than 200 psig pressure for a period of not less than two (2) hours or 50 psi above static pressure in excess of 150 psi for two (2) hours with no pressure drop in the system.

D. All testing shall be witnessed by a representative of the Engineer or Owner and the Authority Having Jurisdiction when required.

E. Where jurisdictional authority's standards are more stringent than the above test, they shall prevail.

F. Furnish copies of Aboveground Test Certificate with close-out documentation.

END OF SECTION 211313
PART 1  GENERAL

1.01  SECTION INCLUDES
   A.  Piping insulation.
   B.  Jackets and accessories.

1.02  RELATED REQUIREMENTS
   A.  Specifications throughout all divisions of the project manual are directly applicable to this section, and this section is directly applicable to them.

1.03  REFERENCE STANDARDS
   A.  The latest published edition of a reference shall be applicable to this project, unless identified by a specific edition date. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this project.
   B.  American Society for Testing and Materials:
   C.  Underwriters Laboratories:

1.04  ACTION SUBMITTALS
   A.  See Section 01 3000 - Administrative Requirements, for submittal procedures.
   B.  Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
   C.  Qualifications Statement: Submit name and qualifications of insulation applicator and name of supervisor for approval within 30-days after award of Contract.

1.05  QUALITY ASSURANCE
   A.  Applicator Qualifications: Company specializing in performing the type of work specified in this section, having a minimum of 5-years experience and approval of the manufacturer.
   B.  Surface Burning Characteristics: Flame spread/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.
   C.  Source Limitations: Obtain insulation of each type through one source from a single manufacturer.
1.06 DELIVERY, STORAGE, AND HANDLING

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

1.07 FIELD CONDITIONS

A. Maintain ambient conditions required by manufacturers of each product.

B. Maintain temperature before, during, and after installation for minimum of 24 hours.

PART 2 PRODUCTS

2.01 RIGID GLASS FIBER INSULATION

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

5. Substitutions: See Section 20 0050 for substitution procedures.

B. Insulation: ASTM C547 and ASTM C795; rigid molded, noncombustible.

1. 'K' value: ASTM C177, 0.24 at 75 degrees F.
2. Maximum service temperature: 850 degrees F.
3. Maximum moisture absorption: 0.2 percent by volume.

C. Vapor Barrier Jacket: White kraft paper with glass fiber yarn, bonded to aluminized film; moisture vapor transmission when tested in accordance with ASTM E96/E96M of 0.02 perm-inches.

D. Vapor Barrier Lap Adhesive: Compatible with insulation.

E. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.

2.02 FLEXIBLE ELASTOMERIC CELLULAR INSULATION

A. Manufacturer:

1. Armacell: armacell.us.
2. Substitutions: See Section 20 0050 for substitution procedures.

B. Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534 Grade 3; use molded tubular material wherever possible. AP Armaflex or approved equal.

1. Minimum Service Temperature: Minus 40 degrees F.
2. Maximum Service Temperature: 220 degrees F.

C. Adhesive: Manufacturer's recommended adhesive, compatible with insulation; AP Armaflex 520.

D. Finish: Manufacturer's recommended finish, compatible with insulation; AP Armaflex WB.

E. Fittings: Suppy preformed flexible elastomeric fittings; no field fabricated fittings.
2.03  JACKETs

A.  PVC or ABS Plastic.
   1.  Jacket: One piece molded type fitting covers and sheet material, off-white color.
      a.  Minimum Service Temperature: 0 degrees F.
      b.  Maximum Service Temperature: 150 degrees F.
      c.  Moisture Vapor Permeability: 0.002 perm inch, maximum, when tested in accordance
          with ASTM E96/E96M.
      d.  Thickness: 10 mil.
      e.  Connections: Pressure sensitive color matching vinyl tape.

   1.  Thickness: 0.016 inch sheet.
   2.  Finish: Smooth.
   4.  Fittings: 0.016 inch thick die shaped fitting covers with factory attached protective liner.
   5.  Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum.

PART 3 EXECUTION

3.01  EXAMINATION

A.  Verify that piping has been tested before applying insulation materials.
B.  Verify that surfaces are clean and dry, with foreign material removed.

3.02  INSTALLATION

A.  Install in accordance with NAIMA National Insulation Standards and manufacturer's instructions.
B.  Glass fiber insulated pipes conveying fluids below ambient temperature:
   1.  Provide vapor barrier jackets, factory-applied or field-applied. Secure with self-sealing
       longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward
       clinch expanding staples and vapor barrier mastic.
   2.  Insulate fittings, joints, and valves with molded insulation of like material and thickness as
       adjacent pipe. Finish with PVC fitting covers.
C.  Insulated pipes conveying fluids below ambient temperature: Insulate entire system including
    fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, etc.
D.  Glass fiber insulated pipes conveying fluids above ambient temperature:
   1.  Provide standard jackets, with or without vapor barrier, factory-applied or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples.
   2.  Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.
E.  Insulated pipes conveying fluids above ambient temperature and less than 140-deg F: Do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
F.  Insulated pipes conveying fluids above ambient temperature and greater than 140-deg F: Insulate entire system including fittings, valves, unions, flanges, strainers, etc.
G. Inserts and Shields:
1. Shields: Piping 1/2-inch diameter or larger. Galvanized steel between pipe hangers and insulation. Tape all shields in place.
2. Insert Application: Piping 2-inch diameter or larger when supported with hangers, 1/2-inch diameter or larger when strut mounted.
3. Insert location: Between support shield and piping and under the finish jacket.
4. Insert configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
5. Insert material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.

H. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions. At fire separations, refer to Division 7.

I. Where piping is exposed, locate insulation and cover seams in the least visible locations. Cover all insulation with protective PVC or aluminum covers within 8-ft of the floor (or as noted).

J. Exterior Applications: Insulate fittings, joints, and valves with pre-formed insulation of like material and thickness as adjoining pipe. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

K. Insulate all above grade storm drainage piping, including roof drain sump bodies.

L. Insulate all plumbing vent piping within 10 feet of the roof penetration.

3.03 SCHEDULE

A. Domestic Systems:
1. Domestic Hot Water Supply:
   a. Glass Fiber Insulation:
      1) Pipe Size Range: All sizes.
      2) Thickness: 1 inch.

2. Domestic Hot Water Recirculation:
   a. Glass Fiber Insulation:
      1) Pipe Size Range: All sizes.
      2) Thickness: 1 inch.

3. Domestic Cold Water Supply:
   a. Glass Fiber Insulation:
      1) Pipe Size Range: All sizes.
      2) Thickness: 1 inch.

4. Domestic Water; Pex Piping:
   a. Flexible Elastomeric Cellular Insulation:
      1) Pipe Size Range: All sizes.
      2) Thickness: 3/4 inch.

B. Drainage Systems:
1. Storm Drain Piping:
   a. Glass Fiber Insulation:
      1) Pipe Size Range: All sizes.
      2) Thickness: 1 inch.

2. Sanitary Vent Piping:
a. Glass Fiber Insulation:
   1) Pipe Size Range: All sizes.
   2) Thickness: 1 inch.

END OF SECTION
PART 1 GENERAL

1.01 SECTION INCLUDES

A. Pipe, fittings, and connections for plumbing piping systems within five feet of the building.
   1. Sanitary sewer.
   2. Domestic water.
   3. Storm water.
   4. Natural gas.

1.02 RELATED REQUIREMENTS

A. Specifications throughout all divisions of the project manual are directly applicable to this section, and this section is directly applicable to them.

B. Water Service Connections:
   1. Provide materials and installation in accordance with the City of Casper Standard Specifications for Public Works Construction and Infrastructure Improvements, current editions.
   2. Note specific requirements for sacrificial anodes, underground nuts/bolts and restraining rods, epoxy coated fittings, etc.
   3. These specifications are available from the City of Casper Engineering Department located at 200 North David Street, Casper, WY 82601.

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this project, unless identified by a specific edition date. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this project.

B. American National Standards Institute:

C. American Society of Mechanical Engineers:
   1. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300.
   2. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.
   3. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
   4. ASME B31.2 - Fuel Gas Piping.
   5. ASME B31.9 - Building Services Piping.
   6. ASME (BPV IV) - Boiler and Pressure Vessel Code, Section IV - Rules for Construction of Heating Boilers.

D. American Society for Testing and Materials:

E. American Water Works Association:
1. AWWA C111/A21.11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
2. AWWA C151/A21.51 - Ductile-Iron Pipe, Centrifugally Cast, for Water.
3. AWWA C651 - Disinfecting Water Mains.

F. Cast Iron Soil Pipe Institute:

G. Manufacturers Standardization Society of the Valve and Fitting Industry:
2. MSS SP-80 - Bronze Gate, Globe, Angle and Check Valves.
3. MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.

H. National Fire Protection Association:

I. National Sanitation Foundation:
1. NSF 61 - Drinking Water System Components - Health Effects.
2. NSF 372 - Drinking Water System Components - Lead Content.

J. Plastic Pipe Institute:
1. PPI TR-4 - PPI Listing of Hydrostatic Design Basis (HDB), Hydrostatic Design Stress (HDS), Strength Design Basis (SDB), Pressure Design Basis (PDB), and Minimum Required Strength (MRS) Ratings For Thermoplastic Piping Materials or Pipe.

1.04 ACTION SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalog information. Indicate valve data and ratings.
1. Piping submittals must be clearly identified with intended service and range of sizes indicated.
2. Valves and other accessory submittals shall be identified to correspond with the piping submittals.

1.05 INFORMATIONAL SUBMITTALS

A. Test Reports: Provide evidence of piping system pressure and leak tests. Include date, section tested, test pressure, and results.

B. Test Reports: Provide evidence of disinfection and bacteriological results of each outlet tested conforming to standards of State and Federal safe drinking water acts.

1.06 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of valves.

B. Operation and Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views, etc.

1.07 QUALITY ASSURANCE

A. Perform work in accordance with applicable codes.

B. Valves: Manufacturer's name and pressure rating marked on valve body.

C. Identify pipe with marking including size, ASTM material classification, ASTM specification, potable water certification, water pressure rating.

D. NSF Standard: Comply with NSF 372 - Drinking Water System Components - Lead Content, for materials that will be in contact with potable water.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.

B. Provide temporary protective coating on cast iron and steel valves.

C. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

D. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.09 FIELD CONDITIONS

A. Do not install underground piping when bedding is wet or frozen.

PART 2 PRODUCTS

2.01 SANITARY SEWER PIPING, BELOW GRADE

A. Solid Wall PVC Pipe: ASTM D2665, Schedule 40.
   1. PVC Socket Fittings: ASTM D2665, to fit Sch 40 pipe.
2.02 SANITARY SEWER PIPING, ABOVE GRADE

A. Hubless Cast Iron Pipe: ASTM A888 or CISPI 301, service weight.
   1. Fittings: Cast iron ASTM A888 or CISPI 301.

2.03 WATER PIPING, BELOW GRADE

   1. Fittings: Ductile or grey iron, standard thickness.

B. ASTM ECOFLEX POTABLE PEX DISTRIBUTION SYSTEM MATERIALS
   1. Service Tubing:
      a. Material: Crosslinked polyethylene (PEX) is manufactured to PEX-a or Engel-method standard and NSF-certified SDR-9.
      b. Material Standard: Materials are manufactured in accordance with ASTM F876, F877, CSA B137.5 and NSF-pw.
      c. Pressure Ratings: Hydrostatic design and pressure ratings are in accordance with the ASTM standard.
      d. Nominal Inside Diameter: Provide tubing with nominal inside diameter in accordance with ASTM F876, as indicated. Note: Numbers in brackets are the metric equivalent pipe size.
   2. Outer Jacket
      a. Material: Corrugated seamless high-density polyethylene (HDPE)
      b. The HDPE jacket completely encompasses and protects the insulation from moisture and damage.
      c. Outer jacket will be extruded directly over the insulation and is flexible.

2.04 WATER PIPING, ABOVE GRADE

A. Copper Tube: ASTM B88, Type L, Drawn (H).
   1. Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought copper and bronze.

B. Cross-Linked Polyethylene Pipe (PEX): ASTM F876 or ASTM F877.
   1. Fittings: Lead-free brass or engineered polymer.
   2. Joints: Mechanical compression fittings.

2.05 STORM WATER PIPING, BELOW GRADE

A. Solid Wall PVC Pipe: ASTM D2665, Schedule 40.
   1. PVC Socket Fittings: ASTM D2665, to fit Sch 40 pipe.

2.06 STORM WATER PIPING, ABOVE GRADE

A. Hubless Cast Iron Pipe: ASTM A888 or CISPI 301, service weight.
   1. Fittings: Cast iron ASTM A888 or CISPI 301.
2. Couplings: ASTM C1277 or CISPI 310, neoprene gaskets and stainless steel clamp-and-shield assemblies.

2.07 NATURAL GAS PIPING, ABOVE GRADE

A. Steel Pipe: ASTM A53 Schedule 40 black.
   1. Fittings: ASME B16.3, malleable iron, or ASTM A234, wrought steel welding type.

2.08 FLANGES, UNIONS, AND COUPLINGS

A. Unions for Pipe Sizes 2 Inches and Under:
   1. Ferrous pipe: Class 150 malleable iron threaded unions.
   2. Copper tube and pipe: Class 150 bronze unions with soldered joints.

B. Flanges for Pipe Size Over 2-1/2” and Over:
   1. Ferrous pipe: Class 150 malleable iron threaded or forged steel slip-on flanges; preformed neoprene gaskets.
   2. Copper tube and pipe: Class 150 slip-on bronze flanges; preformed neoprene gaskets.

C. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.
   1. Precision Plumbing Products (PPP) Clearflow Dielectric Waterway or equal.

2.09 HANGERS AND SUPPORTS

A. Provide hangers and supports that comply with MSS SP-58.
   1. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
   2. Overhead Supports: Individual steel rod hangers attached to structure or to trapeze hangers.
   3. Trapeze Hangers: Welded steel channel frames attached to structure with U-bolt guides.
   4. Hanger Rods: Mild steel threaded both ends or continuous threaded.
   5. Vertical Pipe Support: Steel riser clamp.

B. Plumbing Piping - Drain, Waste, and Vent:
   1. Hangers for Pipe Sizes 1/2 Inch to 2 Inches: Malleable iron, adjustable swivel, split ring.
   2. Hangers for Pipe Sizes 2-1/2 Inches and Over: Carbon steel, adjustable, clevis.

C. Plumbing Piping - Water:
   1. Hangers for Pipe Sizes 1/2 Inch to 2 Inches: Malleable iron, adjustable swivel, split ring.
   2. Hangers for Cold Pipe Sizes 2-1/2” and Over: Carbon steel, adjustable, clevis.

D. Rigidly mounted domestic piping (where allowed) shall be secured to 12 gauge 1-5/8 inch slotted channel framing with insulated strut clamps.

E. Install steel safety plates on upright stud members to prevent drills and fasteners from penetrating piping.

F. Metal stud insulating pipe clamps shall be used to isolate piping from steel stud framing.

G. All insulated piping shall be installed with sufficient clearance to accept continuous insulation.
2.10 FLOW CONTROLS

A. Manufacturers:
   4. Substitutions: See Section 20 0050 for substitution procedures.

B. Manual Type: Class 125, lead-free brass or bronze body with union on inlet, temperature and pressure test plug on inlet and outlet, blowdown/backflush drain.

C. Autoflow Type: NSF/ANSI 61-G certified and approved with series 300 stainless steel body and o-ring type union with stainless steel internal flow cartridge permanently marked with the flow rate and spring range.

2.11 RELIEF VALVES

A. Manufacturers:
   3. Substitutions: See Section 20 0050 for substitution procedures.

B. Pressure Relief: AGA Z21.22 certified, bronze body, teflon seat, steel stem and springs, automatic, direct pressure actuated.

C. Temperature and Pressure Relief: AGA Z21.22 certified, bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, temperature relief maximum 210 degrees F, capacity ASME (BPV IV) certified and labelled.

2.12 STRAINERS

A. Manufacturers:
   3. Substitutions: See Section 20 0050 for substitution procedures.

B. Size 2 inch and Under:
   1. Threaded brass body for 175 psi CWP, wye-pattern with 1/32 inch stainless steel perforated screen.
   2. Class 150, threaded bronze body 300 psi CWP, wye-pattern with 1/32 inch stainless steel perforated screen.

C. Size 2-1/2 inch to 4 inch:
   1. Class 125, flanged iron body, wye-pattern with 1/16 inch stainless steel perforated screen.

2.13 GAS PRESSURE REGULATORS

A. Manufacturers:
   1. Maxitrol Company: maxitrol.com
   2. Fisher Controls International: fisherregulators.com
   3. Substitutions: See Section 20 0050 for substitution procedures.
2.14 GAS VALVES
A. Manufacturers:
   1. Conbraco Industries: apollovalves.com
   2. AY McDonald Manufacturing: aymcdonald.com
   3. Mueller Streamline Company: muellerindustries.com
   4. Substitutions: See Section 20 0050 for substitution procedures.
B. Sizes 4 Inches and Smaller: MSS SP-110, Class 125, 600 psi WOG, two-piece body, chrome plated brass ball, full-port, reinforced teflon seats, blow-out proof stem, threaded ends, suitable for natural gas service.

2.15 SERVICE LINE RISERS
A. Factory fabricated and leak-tested, anodeless service line riser consisting of an underground PE pipe complying with ASTM D2513, SDR 11 inlet connected to a steel pipe complying with ASTM A53, Schedule 40 black steel, Type E, S, or B, with corrosion protective covering.
   1. Outlet shall be threaded or flanged or suitable for welded connection.
   2. Bridging sleeve over mechanical coupling.
   3. Factory connected anode.
   4. Tracer wire connection.
   5. Ultraviolet shield.
   6. Stake supports with factory finish to match steel pipe casing or carrier pipe.

2.16 DRAIN VALVES
A. Drain valves shall be ball valves as specified herein or ball valves as part of an integral flange isolator product. All drain valves shall be fitted with American standard hose thread fittings and blind hose caps.

PART 3 EXECUTION

3.01 EXAMINATION
A. Verify that excavations are to required grade, dry, and not over-excavated.

3.02 PREPARATION
A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
B. Remove scale and dirt, on inside and outside, before assembly.
C. Prepare piping connections to equipment with flanges or unions.
D. Where modifications to layouts are proposed, the contractor shall include wall cleanouts after every 135-degrees of turn. Floor cleanouts will be considered as a last resort only.

3.03 PLUMBING PIPING INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Do not install below grade piping when bedding is wet or frozen.

C. Provide non-conducting dielectric connections wherever jointing dissimilar metals.

D. Route piping in orderly manner and maintain gradient. Route parallel and perpendicular to walls.

E. Install piping to maintain headroom, conserve space, and not interfere with use of space.

F. Group piping whenever practical at common elevations.

G. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

H. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.

I. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with the general contractor.

J. Establish elevations of buried piping outside the building to ensure not less than 6.0 ft of cover.

K. Install vent piping penetrating roofed areas to maintain integrity of roof assembly.

L. Excavate and backfill in accordance with applicable Division 31 specifications.

M. Install bell and spigot pipe with bell end upstream.

N. Install water piping to ASME B31.9.

O. Sleeve all piping passing through partitions, walls, and floors. Install escutcheons on exposed, finished side of penetrations.

P. Inserts:
   1. Provide inserts for placement in concrete formwork.
   2. Install inserts to extend 1-inch above the finished floor elevation in plumbing chases and mechanical equipment rooms.
   3. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

Q. Pipe Hangers and Supports:
   1. Install in accordance with ASME B31.9 and MSS SP-89.
   2. Support all piping in accordance with Chapter 3 of the most current International Plumbing Code (IPC). Install sway bracing and restraints to resist movement.
   3. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
   4. Place hangers within 12 inches of each horizontal elbow.
   5. Use hangers with 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
7. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
8. Prime coat exposed steel hangers and supports.
9. Provide hangers adjacent to motor driven equipment with vibration isolation.
10. Support cast iron drainage piping at every joint.
11. Provide galvanized hangers, supports, and accessories in locations exterior to the building.

R. Install valves with stems upright or horizontal, not inverted.
S. Plug all open ends of incomplete piping work prevent the entrance of dirt and debris.
T. Install all pipe mounted temperature control devices (thermowells, valves, flow meters, etc).
U. Pex Piping Limitations:
   1. The use of pex piping shall be limited to 1” size and below, serving vertical run-outs to individual fixtures or bathrooms groups within the wall framing and downstream of isolation valves, with firmly secured copper ell stub-outs at the fixtures.
   2. Main branch piping shall not be installed with pex. Do not install pex piping to flush valve water closets and urinals. Do not install pex piping within a return air plenum (rated or otherwise).
   3. Support pex piping at all changes in direction and at 32 inch intervals consistent with code requirements and/or local ordinance.
V. Install permanent labels designating "overflow" at all appropriate discharge spout locations.
W. Provide drain valves at all equipment, at all low spots in the systems, at the base of all risers, and on the downstream side of all section valves so any given section may be drained.

3.04 OUTDOOR GAS PIPING INSTALLATION
A. Comply with NFPA 54 for installation and purging of natural-gas piping.
B. Install underground natural-gas piping buried at least 36-inches below finished grade. If installed less than 36-inches, install within a containment conduit.
C. Install underground polyethylene natural-gas piping according to ASTM D2774. Install free of splices or joints unless otherwise approved in writing.
D. Install factory fabricated and leak tested anodeless service line risers at all locations where natural-gas piping transitions from above and below ground installation.

3.05 INDOOR GAS PIPING INSTALLATION
A. Comply with NFPA 54 for installation and purging of natural-gas piping.
B. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
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.
E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
F. Locate valves for easy access.
G. Install piping free of sags and bends.
H. Install fittings for changes in direction and branch connections.
I. Verify final equipment locations for roughing-in.
J. Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying.
K. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped.
L. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe.
M. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
N. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.
O. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
P. Connect branch piping from top or side of horizontal piping.
Q. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
R. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.
S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in these specifications.
T. Plug all open ends of incomplete piping work prevent the entrance of dirt and debris.

3.06 CONNECTIONS
A. Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following: PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 appendixes.
B. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.
C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Apply appropriate tape or thread compound to external pipe threads.
D. Join copper tube and fittings with soldered joints according to ASTM B 828. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.
E. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.

3.07 APPLICATION
A. Install unions downstream of valves and at equipment or apparatus connections.
B. Install brass male adapters each side of valves in copper piped system. Solder adapters to pipe.
C. Install ball valves for shut-off and to isolate equipment, parts of systems, or vertical risers.

D. Provide spring loaded check valves on discharge of water pumps.

E. Provide plug valves in natural gas systems for shut-off service.

F. Provide flow controls in water recirculating systems where indicated.

G. Provide brass or copper nipples at trap arms and dirty arms. Galvanized piping is not permitted.

H. Provide brass nipples at all domestic piping equipment connections. Galvanized piping is not permitted.

I. Exposed accessories beneath sinks and lavatories shall include chrome plated brass p-traps and extensions, quarter-turn angle stops, and braided stainless steel flexible supplies.

3.08 TOLERANCES

A. Drainage Piping: Establish invert elevations within 1/2 inch vertically of location indicated and slope to drain at minimum of 1/8 inch per foot slope.

B. Water Piping: Slope at minimum of 1/32 inch per foot and arrange to drain at low points.

3.09 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

A. Prior to starting work, verify system is complete, flushed and clean.

B. Ensure pH of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda ash) or acid (hydrochloric).

C. Inject disinfectant, free chlorine in liquid, powder, tablet or gas form, throughout system to obtain 50 to 80 mg/L residual.

D. Bleed water from outlets to ensure distribution and test for disinfectant residual at minimum 15 percent of outlets.

E. Maintain disinfectant in system for 24 hours.

F. If final disinfectant residual tests less than 25 mg/L, repeat treatment.

G. Flush disinfectant from system until residual equal to that of incoming water or 1.0 mg/L.

H. Take samples no sooner than 24 hours after flushing, from 10 percent of outlets and from water entry, and analyze in accordance with AWWA C651.

3.10 SERVICE CONNECTIONS

A. Provide new sanitary sewer services. Before commencing work check invert elevations required for sewer connections, confirm inverts and ensure that these can be properly connected with slope for drainage and cover to avoid freezing.

B. Provide new gas service complete with gas meter and regulators. Gas service distribution piping to have initial minimum pressure of 2 psi. Provide regulators on each line serving gravity type appliances, sized in accordance with equipment.
3.11 FIELD QUALITY CONTROL

A. Testing and Inspection:
   1. General: All new, altered, extended, or replaced plumbing piping systems shall be tested and inspected in accordance with the following requirements and the authority having jurisdiction.
   2. Tests shall be applied to systems in their entirety or in completed sections. Repair any leaks that may occur and repeat the test procedure.
   3. Record and submit test and inspection reports for each system, complete with diagram or description of section tested and any corrective action taken.
   4. Drainage Piping: Sanitary and storm systems shall be filled with water and tested with no less than a 10 foot head of water. The pressure shall be held for not less than 15 minutes.
   5. Water Piping: Supply systems shall be tested under a water pressure not less than 125% of the expected working pressure of the system. The pressure shall be held for not less than 6 hours.
   6. Gas Piping: Gas piping systems shall be installed, examined, inspected, and tested in accordance with requirements of the International Fuel Gas Code and the authority having jurisdiction.

3.12 SCHEDULES

A. Pipe Hanger Spacing:
   1. Metal Piping:
      a. Pipe size: 1/2 inches to 1-1/4 inches:
         1) Maximum hanger spacing: 6 feet.
         2) Hanger rod diameter: 3/8 inches.
      b. Pipe size: 1-1/2 inches to 2 inches:
         1) Maximum hanger spacing: 10 feet.
         2) Hanger rod diameter: 3/8 inch.
      c. Pipe size: 2-1/2 inches to 3 inches:
         1) Maximum hanger spacing: 10 feet.
         2) Hanger rod diameter: 1/2 inch.
      d. Pipe size: 4 inches to 6 inches:
         1) Maximum hanger spacing: 10 feet.
         2) Hanger rod diameter: 5/8 inch.
   2. Plastic Piping:
      a. All Sizes:
         1) Maximum hanger spacing: 6 feet.
         2) Hanger rod diameter: 3/8 inch.
   3. Pex Piping:
      a. All Sizes:
         1) Maximum hanger spacing: 32 inches.

END OF SECTION
PART 1 GENERAL

1.01 SECTION INCLUDES
A. Water heaters.
B. Thermal expansion tanks.
C. Inline circulating pumps.

1.02 RELATED REQUIREMENTS
A. Specifications throughout all divisions of the project manual are directly applicable to this section, and this section is directly applicable to them.

1.03 REFERENCE STANDARDS
A. The latest published edition of a reference shall be applicable to this project, unless identified by a specific edition date. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this project.
B. National Sanitation Foundation:
   1. NSF 61 - Drinking Water System Components - Health Effects.
   2. NSF 372 - Drinking Water System Components - Lead Content.

1.04 ACTION SUBMITTALS
A. See Section 01 3000 - Administrative Requirements, for submittals procedures.
B. Product Data: For each type of product indicated:
   1. Include construction details, material descriptions, dimensions of individual components and profiles.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   3. Include wiring diagrams for power, signal, and control wiring.
   4. Provide certified pump curves showing pump performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable.

1.05 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: Include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.
B. Warranty Documentation: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.

1.06 QUALITY ASSURANCE
A. Source Limitations: Obtain hydronic pumps and accessories of each type through one source from a single manufacturer.
B. NSF Compliance: Comply with NSF/ANSI 61 and NSF/ANSI 372 for lead-free plumbing requirements.

C. Electrical Components: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. UL Compliance: Comply with UL 778 for motor operated water pumps.

E. Identification: Provide pumps with manufacturer's name, model number, and rating/capacity identified by permanently attached label.

1.07 DELIVERY, STORAGE, AND HANDLING
A. Provide temporary inlet and outlet caps. Maintain caps in place until installation.

PART 2 PRODUCTS

2.01 DOMESTIC WATER STORAGE TANKS
A. Manufacturers:
   3. Substitutions: See Section 20 0050 for substitution procedures.

B. Tank: Glass lined welded steel ASME labeled; thermally insulated with minimum 2 inches glass fiber, encased in corrosion-resistant steel jacket; baked-on enamel finish; floor shield and legs.

C. Accessories: Tank drain, water inlet and outlet, thermometer range of 40 to 200 degrees F, ASME pressure relief valve suitable for maximum working pressure.

2.02 THERMAL EXPANSION TANKS
A. Manufacturers:
   3. Wessels Company: westank.com
   4. Substitutions: See Section 20 0050 for substitution procedures.

B. Construction: Welded steel, tested and stamped in accordance with ASME BPVC-VIII-1; supplied with National Board Form U-1, rated for working pressure of 125 psig, with flexible EPDM diaphragm sealed into tank, and steel legs or saddles.

C. Accessories: Pressure gauge and air-charging fitting, tank drain with ball valve and hose thread fitting.

2.03 IN-LINE CIRCULATOR PUMPS
A. Manufacturers:
   1. Wilo: wilo-usa.com
   2. Taco: taco-hvac.com
   3. Grundfos: www.us.grundfos.com
B. NSF/ANSI 61 approved lead-free, bronze or stainless steel casing, direct connected with wet rotor motor for inline mounting, rated for 125 psig working pressure, 230 degrees F water temperature.

2.04 ELECTRICAL WORK

A. Provide electrical motor driven equipment specified complete with motors, motor starters, controls, and wiring.

B. Electrical characteristics to be as specified or indicated.

C. Furnish motor starters complete with thermal overload protection and other appurtenances necessary for the motor control specified.

D. Supply manual or automatic control and protective or signal devices required for the operation specified, and any control wiring required for controls and devices not shown.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install plumbing equipment in accordance with manufacturer's instructions, as required by code, and complying with conditions of certifications.

B. Coordinate with plumbing piping and related electrical work to achieve operating system.

C. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.

D. Pipe relief valves and drains to the nearest floor drain.

E. Install condensate collectors and pipe to the nearest floor drain.

F. Install drain valves with hose-ends and caps at all tanks, etc.

3.02 TESTING:

A. Perform each visual and mechanical inspection required by the manufacturer.

B. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.03 SCHEDULES

A. See equipment schedules on the drawings for Basis of Design.
16121.00 CNCIA Holdroom
Addition/Renovation

22 3000-4

PLUMBING EQUIPMENT
SECTION 22 4200
PLUMBING FIXTURES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Water closets.
B. Urinals.
C. Lavatories.
D. Sinks.
E. Mop basins.
F. Water coolers.

1.02 RELATED REQUIREMENTS

A. Specifications throughout all divisions of the project manual are directly applicable to this section, and this section is directly applicable to them.

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this project, unless identified by a specific edition date. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this project.

B. American National Standards Institute:

C. American Society of Mechanical Engineers:
   1. ASME A112.6.1M - Supports for Off-the-Floor Plumbing Fixtures for Public Use.
   2. ASME A112.18.1 - Plumbing Supply Fittings.
   3. ASME A112.19.2 - Ceramic Plumbing Fixtures.
   4. ASME A112.19.3 - Stainless Steel Plumbing Fixtures.
   5. ASME A112.19.5 – Flush Valves and Spuds for Water Closets, Urinals, and Tanks

D. American Society of Sanitary Engineering:
   1. ASSE 1016 – Performance Requirements for Individual Automatic Compensating Valves.
   2. ASSE 1037 - Performance Requirements for Pressurized Flushing Devices for Plumbing Fixtures
   3. ASSE 1070 – Performance Requirements for Water Temperature Limiting Devices.
   4. ASSE 1071 – Performance Requirements for Temperature Actuated Mixing Valves.

E. National Sanitation Foundation:
   1. NSF 61 - Drinking Water System Components - Health Effects.
   2. NSF 372 - Drinking Water System Components - Lead Content.
1.04 ACTION SUBMITTALS
A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.
   1. Include selected fixture and trim, fittings, accessories, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates for each type of fixture indicated.
      a. Each fixture and all related accessory trim shall be submitted grouped together and clearly identified to correspond with the individually scheduled mark.
      b. Submittals with cut sheets referencing multiple fixtures and/or not grouped according to the scheduled mark will be returned without review.
      c. Color to be manufacturer's standard commercial bright white unless noted otherwise.

1.05 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For fixtures, faucets, flush valves, and electronic sensors to include in operation and maintenance manuals. Include fixture trim exploded view and replacement parts lists.
B. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.06 QUALITY ASSURANCE
A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each source through one source from a single manufacturer, unless specifically indicated otherwise.
B. Products Requiring Electrical Connection: Listed and labeled as defined in NFPA 70, by Underwriters Laboratories, and marked for intended use.
C. Regulatory Requirements: Comply with requirements in ANSI A117 and Americans with Disabilities Act regarding plumbing fixture for people with disabilities.
D. NSF Standard: Comply with NSF 372 - Drinking Water System Components - Lead Content, for faucet materials that will be in contact with potable water.

1.07 DELIVERY, STORAGE, AND HANDLING
A. Accept fixtures on site in factory packaging. Inspect for damage.
B. Protect installed fixtures from damage by securing areas and by leaving factory packaging in place to protect fixtures and prevent use.
C. All fixtures shall be protected from damage to the date of final acceptance of the project. Any fixture or component found defective or damaged shall be replaced, not repaired.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS
A. All plumbing fixtures and trim shall be of one make, except where noted otherwise. All trim shall consist of chrome-plated brass, including faucet spouts and handles unless otherwise specified.
B. All plumbing fixtures shall be set level and plumb, spaced in accordance with the architectural drawings, and securely installed so as to be absolutely rigid. Provide sealant at all mounting surfaces.

C. All hot and cold water connections shall be provided with chrome plated annealed supplies and angle stops. All wall penetrations shall be finished with chrome-plated escutcheons for complete coverage.

D. All wall mounted fixtures shall be installed with floor mounted, concealed arm type carrier supports, for the wall depths shown on the architectural drawings.

2.02 WATER CLOSETS

A. Water Closets: ASME A112.19.2; vitreous china, floor-mounted or wall-hung with elongated rim.
   1. Flush Volume: 1.6 gallon, maximum.
   2. Flush Style: Siphon jet flush action.
   3. Flush Valve: Exposed (top spud).
   6. Outlet Size: 3-inch.

B. Flush Valves: ASSE 1037, diaphragm type, with integral check stops and backflow device.
   1. Sensor Type: Solenoid operator, hard wired, infrared sensor and over-ride push button.
   2. Exposed Type: Chrome plated, escutcheon, integral screwdriver stop.

C. Seats: Solid plastic, elongated rim, open front, extended back, self-sustaining hinge, brass bolts, without cover, white in color.

D. Carriers: ASME A112.6.1M; adjustable cast iron frame, integral drain hub and vent, adjustable spud, lugs for floor and wall attachment, threaded fixture studs with nuts and washers.

2.03 URINALS

A. Urinals: ASME A112.19.2; vitreous china, wall hung with side shields and integral trap.
   1. Flush Volume: 1.0 gallon, maximum.
   2. Flush Style: Washout flush action.
   3. Flush Valve: Exposed (top spud).
   5. Supply Size: 3/4-inch.
   6. Outlet Size: 2-inch.

B. Flush Valves: ASSE 1037, diaphragm type, with integral check stops and backflow device.
   1. Sensor Type: Solenoid operator, hard wired, infrared sensor and over-ride push button.
   2. Exposed Type: Chrome plated, escutcheon, integral screwdriver stop.

C. Carriers: ASME A112.6.1M; type I urinal carrier, cast iron and steel frame, with fixture support plates and coupling with seal for wall-mounting urinal-type fixture. Include steel uprights with feet.

2.04 LAVATORIES

A. Wall-Mounted: ASME A112.19.2; vitreous china, rectangular basin with splash lip, ledge back, front overflow, and soap depression.
B. Counter-Mounted: ASME A112.19.2; vitreous china, self-rimming, oval or round basin with front overflow and soap depressions.

C. Undercounter-Mounted: ASME A112.19.2; vitreous china, oval or round basin with front overflow and soap depression.

D. Supply Faucet: ASME A112.18.1; brass body, chrome plated supply fitting with indexed handles, open grid strainer, and water economy aerator with maximum flow of 2.2-gal per minute.

E. Accessories:
   1. Chrome-plated 17-gauge brass p-trap and arm with escutcheon.
   2. Offset waste with perforated open strainer.
   3. Screwdriver or loose-key quarter-turn stops.
   4. ASSE 1070 solid brass temperature limiting valves.
   5. Chrome-plated rigid or flexible supplies with escutcheons.
   6. ADA compliant protective pipe covers where indicated.

F. Carriers: ASME A112.6.1M; type II lavatory carrier, cast iron and steel frame, with concealed arms and tie rod for wall-mounting lavatory-type fixture. Include rectangular steel uprights for accessible fixtures.

2.05 SINKS

A. Counter-Mounted: ASME A112.19.3; 18-gauge, Type 304 stainless steel, self-rimming and undercoated, with ledge back drilled for trim.

B. Supply Faucet: ASME A112.18.1; brass body, chrome plated supply fitting with indexed handles, open grid strainer, and water economy aerator with maximum flow of 2.2-gal per minute.

C. Accessories:
   1. Chrome plated 17-gauge brass p-trap and arm with escutcheon.
   2. Basket strainer or offset waste with perforated open strainer.
   3. Screwdriver or loose-key quarter-turn stops.
   4. ASSE 1070 solid brass temperature limiting valves.
   5. Chrome-plated rigid or flexible supplies with escutcheons.
   6. ADA compliant protective pipe covers where indicated.

2.06 MOP SERVICE BASINS

A. Mop Basin: White molded stone, floor mounted, with one inch wide shoulders, stainless steel strainer.

B. Trim: ASME A112.18.1 exposed wall type supply with cross handles, spout wall brace, vacuum breaker, hose end spout, strainers, eccentric adjustable inlets, integral screwdriver check stops with covering caps and adjustable threaded wall flanges.

C. Accessories:
   1. Plain end reinforced plastic hose, 1/2-inch diameter, 5-ft length.
   2. Hose clamp hanger.
   3. Mop hanger.
2.07 DRINKING FOUNTAINS

A. Water Cooler: Electric, mechanically refrigerated; surface handicapped mounted; stainless steel top, stainless steel body, elevated anti-squirt bubbler with stream guard, automatic stream regulator, push bar controls, touchless bottle filling station, with integral air cooled condenser and stainless steel grille.
   1. Capacity: 8-gal per minute of 50-deg F water with inlet at 80-deg F and room temperature of 90-deg F, when tested in accordance with ASHRAE Std 18.
   2. Electrical: 115 V, 60 Hertz compressor, 6-foot cord and plug for connection to electric wiring system including grounding connector.
   3. Bottle Filling Station: Sanitary, touchless activation with auto 20-sec shut-off timer, 1.1-gal per minute laminar flow, where indicated.

2.08 PROTECTIVE PIPE COVERS

A. Manufactured plastic wraps for covering plumbing fixture hot and cold water supplies and trap and drain piping. Comply with ADA requirements.
   1. Single or multi-piece design, non-absorbent, uv-inhibited, anti-microbial surface with white finish and tamper-resistant fastening system.
   2. Tested in compliance with ASTM E84, with a 25 flame spread index and 450 smoke developed index.

2.09 FITTINGS FOR PLUMBING FIXTURES

A. Refer to plumbing fixtures schedules on the drawings for specific accessories and fittings. Other miscellaneous fittings include:
   1. Supply Stops: Chrome-plated brass, angle or straight, quarter-turn ball-type or compression valve, same size as indicated supply.
   2. Supply Piping: Chrome-plated-brass pipe, or chrome-plated copper tube, or braided stainless steel flexible connectors matching water-supply piping size. Include chrome-plated-brass or stainless-steel wall flange.
   3. Traps: Tubular brass with 17-gauge wall thickness, slip-joint inlet, wall-flange, escutcheons, and size as indicated on the drawings. Use chrome-plated tube for exposed applications.
   5. Indirect Waste: PVC or copper, size to match fixture.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine walls, floors, and casework for suitable conditions where fixtures are to be installed.
B. Examine rough-in for sanitary drainage and vent piping systems and supports to verify actual sizes and locations and types of supports, before fixture installation.
C. Confirm that millwork is constructed with adequate provision for the installation of counter top lavatories and sinks before rough-in and installation.
D. Where applicable, verify that electric power is available and of the correct characteristics.
3.02 PREPARATION
A. Rough-in fixture piping connections in accordance with minimum sizes indicated on the drawings.

3.03 INSTALLATION
A. Install fixtures level and plumb. Assemble fixtures, trim, fittings, and other components according to manufacturer’s written instructions and rough-in drawings.
B. Install accessible, wall-mounted fixtures at mounting height for handicapped/elderly in accordance with ANSI A117.1.
C. Install lever-operated water closets and flush valves for accessible water closets with handle mounted on open side of water closet.
D. Attach supply piping to supports or substrate within pipe spaces behind fixtures so as to be rigid and not subject to push or pull movement.
E. Install supports, affixed to building substrate, for wall-mounted fixtures.
   1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
   2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
   3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.
F. Install counter mounted fixtures in and attached to casework.
G. Install wall-hung, back-outlet urinals onto waste fitting seals and attached to supports.
H. Install trap and waste piping on drain outlet of fixtures that are indicated to be directly connected to drainage system.
I. Install indirect waste piping on drain outlet of fixtures that are indicated to be indirectly connected to drainage system.
J. Install escutcheons at piping penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern if required to conceal protruding fittings.
K. Seal joints between fixtures and walls, floors, and counters using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color.
L. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories and sinks.
M. Install waste disposer in outlet of sinks indicated to have disposer. Install switch where indicated or in wall adjacent to sink if location is not indicated.
N. Double-nut fixture studs at the face plates on all wall-mounted water closet carrier supports.

3.04 ADJUSTING
A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings and controls.
B. Adjust temperature limiting devices to the Owner’s preference. Adjust any rotational limit stops on shower valves to a safe temperature.
C. Operate and adjust disposers and controls. Replace damaged and malfunctioning units.
D. Adjust water pressure for intended water flow rate to fixtures without splashing, noise, or overflow.
E. Replace washers and seals of leaking and dripping faucets and stops.
F. Install new batteries in sensor-operated equipment at the time of close-out.

3.05 CLEANING
A. Clean fixtures, faucets, and fittings with manufacturer’s recommended cleaning methods and materials.
B. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
C. Remove sediment and debris from traps and drains.

3.06 PROTECTION
A. Protect installed products from damage due to subsequent construction operations.
B. Do not allow use of fixtures for temporary facilities unless approved in writing by the Owner.
C. Repair or replace damaged products prior to the date of substantial completion.

3.07 SCHEDULES
A. Fixtures and Faucets: See fixture schedules on the drawings for Basis of Design.
B. Fixture Heights: Install fixtures to heights above finished floor as indicated on the architectural drawings.

END OF SECTION
PART 1 GENERAL

1.01 SUMMARY

A. This section includes:
   1. Neoprene Pads
   2. Neoprene Mountings and Hangers
   3. Spring Isolation Mounts and Hangers
   4. Flexible Connectors

B. Vibration Control Products furnished as integral part of factory-fabricated equipment are specified as part of equipment assembly in other Division 23 sections.

C. Refer to other Division 23 sections for equipment foundations, hangers, sealants, gaskets, requirements of electrical connections to equipment isolated on vibration control products, and requirements of duct connections to air handling equipment isolated on vibration control products.

1.02 NOISE CRITERIA

A. Noise levels due to mechanical or electrical equipment, ductwork, grilles, registers, terminal devices, diffusers, etc., shall not exceed sound pressure levels in all 8 octave bands corresponding to NC levels per ASHRAE handbook as indicated.
   1. Existing and New Holdrooms: NC-35

B. All penetrations by conduit through partitions, floors, and ceilings at spaces listed above, rooms with slab-to-slab acoustical walls, and mechanical and electrical rooms shall be packed with insulation and sealed airtight with non-hardening sealant as described herein.

1.03 SUBMITTALS

A. See Administrative Requirements for submittal procedures.

B. Contractor shall submit fully coordinated shop drawings for noise control equipment. These submittals shall state the acoustical performance of the products as described below.
   1. Duct Silencers: Submit sound attenuation and maximum regenerated noise in octave bands.
   2. AHUs and VAVs: Submit sound power levels (discharge, inlet, casing radiated) in octave bands from 63 Hz through 8000 Hz inclusive obtained in accordance with accepted standards.

C. Isolators – Submit schedule for all vibration isolators indicating the following:
   1. Submit schedule for all vibration isolators indicating the following:
   2. Manufacturer, type, model number, size
   3. Static deflection of each isolation element
4. Spring constant of each spring-type isolation element
5. Estimated imposed load on each isolation element
6. Spring o.d., free operating, and solid heights
7. Design of supplementary bases
8. Seismic restraints
9. Catalog cuts
10. Piping isolators shown and identified on piping layout drawings

1.04 QUALITY ASSURANCE

A. The installation of all noise and vibration control systems shall be under the supervision of the manufacturer's representative.

B. All vibration isolation equipment and materials shall be provided by a single manufacturer. The following manufacturers are approved, provided systems comply with the specified design and performance requirements:

1. Mason Industries, Inc. – Hauppauge, New York (Basis of Design)
2. Vibration Mountings and Controls – Bloomingdale, New Jersey

C. Warranty: Refer to Division 1 for warranty requirements.

PART 2 PRODUCTS

2.01 GENERAL

A. All equipment provided for noise control shall be new and manufactured specifically for the purpose intended.

2.02 MATERIALS

A. Foam Rod

1. Foam backer rod shall be flexible closed-cell polyethylene suitable for use as a backing for non-hardening sealant.

B. Non-Hardening Sealant

1. Sealant for electrical penetrations shall be non-hardening polysulphide type, such as Tremco Acoustical Sealant or equal.
2. Permanently flexible, approved firestop putty of minimum density 40 pcf (640 kg/m3) and maximum hardness of 60 durometer (Shore A) may be used in lieu of the sealant on foam rod in perimeter walls that are fire rated for all rooms rated 40 dBA or less and for rooms with slab-to-slab acoustical walls.

C. Packing Material for Penetrations

1. Glass fiber or mineral fiber shall be used as specified herein for packing of penetrations through walls and slabs of rooms rated 40 dBA or less, rooms with slab-to-slab acoustical walls, and mechanical/electrical rooms.
2. Glass or mineral fiber; non-combustible; resistant to water, mildew and vermin. USG Thermafiber, 2.5 pcf density, or equivalent product by Roxul, Inc.

2.03 EQUIPMENT

A. All equipment provided for vibration isolation or noise control shall be new and manufactured specifically for the purpose intended.

B. General:
   1. All vibration isolators shall have either known un-deflected heights or calibration markings so verification can be made after adjustment that loads are within proper range of the device.
   2. All isolators shall operate in the linear portion of their load versus deflection curve.
   3. The theoretical vertical natural frequency for each support point, based upon load per isolator and isolator stiffness, shall not differ from the design objectives for the equipment by more than ±10%.
   4. All neoprene mountings shall possess Shore hardness of 30 to 60 ±5, or as specified herein, after minimum aging of 20 days or corresponding over-aging.
   5. Housed or caged spring isolators are not acceptable.
   6. Mounting assemblies for spring isolators shall utilize bare steel springs with the spring diameter not less than 80% of the loaded operating height of the spring. Each spring isolator shall be designed and installed so that the ends of the spring remain parallel during and after the spring installation. All isolators shall operate in the linear portion of their load/deflection curve and have 50% excess capacity without becoming coil bound.
   7. All mounting systems exposed to weather and other corrosive environments shall be protected with factory corrosion resistance. All metal parts of mountings (except springs and hardware) shall be hot dip galvanized. Springs shall be cadmium plated and neoprene coated. Nuts and bolts shall be cadmium plated.

C. Isolator Type MWP
   1. Type MWP (Metal and Waffle Sandwich Pads) shall consist of two 5/16” thick ribbed or waffle neoprene pads sandwiching a 16 gauge stainless steel plate. The pad shall be designed for 15% strain. Neoprene shall be bridge bearing quality with a maximum durometer of 40.
   2. If the isolator is bolted to the structure, a neoprene vibration isolation washer and sleeve (Uniroyal Type 620/660 or as approved) shall be installed under the bolt head between the steel washer and the base plate.
   3. (Type MWP: Mason Industries Type WSW or as approved.)

D. Isolator Type DDNM
   1. Type DDNM (Double Deflection Neoprene Mounts) shall be laterally stable, double deflecting, molded neoprene isolators. All metal surfaces shall be covered with neoprene. The top and bottom surfaces shall be ribbed, and bolt holes shall be provided in the base. The mounts shall have leveling bolts rigidly secured to the equipment.
   2. The strain on the neoprene shall not exceed 15%. Neoprene shall be bridge bearing quality with a maximum durometer of 40. DDNM mounts shall be selected for a static deflection of 3/8” unless otherwise specified.
   3. (Type DDNM: Mason Industries Type ND or as approved.)
E. Isolator Type DDNH

1. Type DDNH (Double Deflection Neoprene Hangers) shall consist of a molded neoprene element in a steel hanger box. A neoprene sleeve shall be located where the lower hanger rod passes through the steel box supporting the isolator, such that the hanger rod cannot contact the steel hanger body. The diameter of the clear hole in the mounting box shall be at least 3/4” larger than the diameter of the hanger rod and permit the hanger rod to swing through a 30-degree arc. When installed, the hanger box shall be allowed to rotate through a full 360-degree arc without encountering any obstructions.

2. Unless otherwise specified, the static deflection of DDNH hangers shall be 0.3” with a strain not exceeding 15%. Neoprene shall be bridge-bearing quality with a maximum durometer of 40.

3. (Type DDNH: Mason Industries Type HD or as approved.)

F. Isolator Type SPNM

1. Type SPNM (Spring and Neoprene Mounts) shall be free standing and laterally stable without any housing. Springs shall be designed so that the ratio of the horizontal to vertical spring constant is between one and two. The spring diameter shall be not less than 80% of the compressed height of the spring at rated load. Loaded springs shall have a minimum additional travel to solid equal to 50% of the specified static deflection.

2. Unless otherwise specified, the minimum static deflection of SPNM isolators for equipment mounted on grade slabs shall be 1” and the minimum static deflection for equipment mounted above grade level shall be 2”.

3. Two Type WP isolation pads sandwiching a 16 ga. stainless or galvanized steel separator plate shall be bonded to the isolator baseplate.

4. Unless otherwise specified, isolators need not be bolted to the floor for indoor installations. If the base plates are bolted to the structure, a neoprene vibration isolation washer and sleeve (Uniroyal Type 620/660 or as approved) shall be installed under the bolt head between the steel washer and the base plate.

5. (Type SPNM: Mason Industries Type SLF or as approved.)

G. Isolator Type SPNH

1. Type SPNH (Spring and Neoprene Hangers) shall consist of a steel spring in series with a neoprene element. The spring shall have a minimum additional travel to solid equal to 50% of the specified deflection. The neoprene element shall have a static deflection of not less than 0.3” with a strain not exceeding 15%. Neoprene shall be bridge-bearing quality with a maximum durometer of 40.

2. Unless otherwise specified, the static deflection of SPNH hangers shall be 2”.

3. Spring diameter and hanger box hole size shall be large enough to permit the hanger rod to swing through a 30 degree arc. A neoprene sleeve shall be inserted in the steel hanger box where the lower hanger rod passes through it, such that the hanger rod cannot contact the steel hanger body. The diameter of the clear hole in the mounting box shall be at least 3/4” larger than the diameter of the hanger rod. When installed, the spring element shall not be cocked, and the hanger box shall be allowed to rotate through a full 360 degree arc without compromising a minimum clearance of 1”.

4. (Type SPNH: Mason Industries Type 30N or as approved.)
H. Neoprene Mounting Sleeves
   1. Neoprene mounting sleeves for hold down applications of equipment with vibration isolators shall be Uniroyal Type 620/660 or as approved.

I. Flexible Pipe Connections
   1. Flexible connectors for pipes shall be neoprene Safeflex SFU or SFDCR, or as approved. Control cables (Mason Type ACC or equivalent) may be used to prevent axial elongation in the connector. Rigid control rods shall not be used for this purpose.

2.04 DUCT SILENCERS
A. The following duct silencer manufacturers are approved, provided the product complies with the specified design and performance requirements:
   1. Price Industries (Basis-of-Design)
   2. Vibro-Acoustics
   3. IAC Acoustics
   4. Kinetics Noise Control
   5. Pottorff

B. Rectangular duct silencers shall have outer casings of not less than 22-gauge galvanized steel. Seams shall be lock formed and mastic filled. The internal baffles (splitters) shall be not less than 24-gauge galvanized perforated steel having an open area of about 30%. The nosings shall be full radius or airfoil shape.

C. The sound absorbing media shall be not less than 4.5 pcf glass/mineral fiber packed under 5% compression. The fiber fill shall be incombustible, mildew resistant and vermin proof. The sound absorbing material shall be protected from erosion.

D. If the silencer is supplied in modular sections, the silencer shall meet or exceed the specification for single-module silencers with respect to insertion loss, pressure drop, regenerated noise, and air leakage.

PART 3 EXECUTION
3.01 INSPECTION
A. Examine areas and conditions under which vibration control units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Owner or his representative.

3.02 PERFORMANCE OF ISOLATORS
A. Comply with minimum static deflections recommended by ASHRAE, for selection and application of vibration isolation materials and units, unless otherwise noted.

B. Manufacturer’s recommendations: Except as otherwise indicated, comply with manufacturer’s recommendations for selection and application of vibration isolation materials and units to achieve minimum static deflection and displacement requirements.

3.03 APPLICATIONS
A. Except as otherwise indicated, select vibration control products in accordance with ASHRAE Handbook, 2015 HVAC Applications Volume, Chapter 48, “Noise and Vibration Control,” Table 47.

B. Piping: For piping connected to equipment mounted on vibration control products, install
isolation hangers (Type SPNH), as indicated, for the first three (3) points of support for pipe sizes 4" and less, for first four (4) points of support for pipe sizes 6" through 8", and for first six (6) points of support for pipe sizes 10" and over.

C. All equipment, piping, etc. shall be mounted on or suspended from approved foundations and supports as specified herein or as shown on the drawings.

D. Furnish and install neoprene mounting sleeves for hold down bolts to prevent any metal to metal contact.

E. All equipment shall be provided with lateral restraining isolators as required to limit horizontal motion to 1/4" maximum, under all operating conditions. Lateral restraining isolators shall have the same static deflection as equipment being isolated.

F. Piping, ductwork, conduit or mechanical equipment shall be supported from building structure, not hung from or supported on other equipment, pipes, or ductwork.

G. All wiring connections to mechanical equipment on isolators shall be made with flexible conduit fabricated in a slack shape.

H. Elastomeric isolators that will be exposed to temperatures below 32° F shall be fabricated from natural rubber instead of neoprene.

I. Springs shall be sized to be non-resonant with equipment forcing frequencies or support structure natural frequencies.

3.04 INSTALLATION

A. Except as otherwise indicated, comply with manufacturer’s instructions for installation and load application to vibration isolation materials and units. Adjust to ensure that units do not exceed rated operating deflections or bottom out under loading, and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices (if any) intended for temporary protection against overloading during installation.

B. Install units between substrate and equipment as required for secure operation and to prevent displacement by normal forces.

C. Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where substrate is not level.

D. Locate isolation hangers as near overhead support structure as possible.

E. Flexible Pipe Connectors: Install on equipment side of shutoff valves, horizontally and parallel to equipment shafts wherever possible. The connectors shall be used to connect piping diameter 2" or greater to reciprocating or rotating equipment.

F. Air Handling Unit (AHU-1)

1. The fans shall be supported internally by spring isolators (Type SPNM) having a static deflection of 1" under actual load.

2. Neoprene pads or mounts (Type MWP or DDNM) are recommended for use with internal compressors. Coordinate internal isolation of compressors with the manufacturer’s recommendations.

G. Inline Exhaust Fans

1. Inline exhaust fans shall be isolated via neoprene hangers (Type DDNH).

2. Duct and pipe connections shall be made with flexible connectors.
H. Circulating Pumps
1. Circulating pumps shall be isolated via neoprene hangers (Type DDNH). Pipe connections shall be made with flexible connectors.

I. Chilled Water Piping
1. Chilled water piping over 2” in diameter shall be vibration isolated from building structure by means of spring isolation hangers with a static deflection of 1” under actual load conditions.
2. Where pipes rise in a vertical chase and are supported from a structure with isolation hangers and require lateral bracing, neoprene riser guides shall be mounted around the pipe to limit lateral movement and to prevent direct contact with the supporting structure.

J. Duct Silencers
1. Duct silencers shall be furnished and installed as shown on the mechanical drawings and as called for in the silencer schedule.

K. Duct and Pipe Isolation
1. Ducts and pipes shall be connected to fans, fan casings and fan plenums by means of flexible connectors. Flexible connectors shall be installed to prevent metal-to-metal contact across flexible connection. Flexible duct connectors shall not be used outside the mechanical room unless expressly shown on the drawings.

L. Duct and Pipe Penetrations
1. Where each duct or pipe passes through a wall, floor or ceiling of a noise-critical space (listed in section 1.02, those rooms with slab-to-slab acoustical partitions, and mechanical rooms), there shall be a clear annular space of 1/2” - 1” between the duct and structure. This also includes all penetrations of roofs and walls from exterior mechanical equipment. After all of the ductwork is installed, the Contractor shall check the clearance, pack the voids full depth with mineral fiber batt insulation and caulk both ends with a non-aging, non-hardening sealant backed by a polyethylene foam rod or permanently flexible firestop material.

3.05 EXAMINATION OF RELATED WORK

A. Installer of vibration isolation work shall observe installation of other work related to vibration isolation work, including work connected to vibration isolation work; and, after completion of other related work (but before equipment start-up), shall furnish written report to Engineer listing observed inadequacies for proper operation and performance of vibration isolation work. Report shall cover, but not necessarily be limited to, the following:
1. Equipment installations (performed as work of other sections) on vibration isolators.
2. Piping connections, including flexible connections.
3. Ductwork connections, including provisions for flexible connections.
4. Passage of piping and ductwork, which is to be isolated through walls and floors.

B. Do not start-up equipment until inadequacies have been corrected in manner acceptable to vibration isolation installer.

C. Clean each vibration control unit, and verify that each is working freely, and that there is no dirt or debris in immediate vicinity of unit that could possibly short-circuit unit isolation.

END OF SECTION
PART 1 GENERAL

1.01 SECTION INCLUDES
A. Duct insulation.

1.02 RELATED REQUIREMENTS
A. Specifications throughout all divisions of the project manual are directly applicable to this section, and this section is directly applicable to them.

1.03 REFERENCE STANDARDS
A. The latest published edition of a reference shall be applicable to this project, unless identified by a specific edition date. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this project.
B. American Society for Testing and Materials:
C. National Fire Protection Association:
D. Underwriters Laboratories:

1.04 ACTION SUBMITTALS
A. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
B. Qualifications Statement: Submit name and qualifications of insulation applicator and name of supervisor for approval within 30-days after award of Contract.

1.05 QUALITY ASSURANCE
A. Applicator Qualifications: Company specializing in performing the type of work specified in this section, having a minimum of 5-years experience and approval of the manufacturer.
B. Surface Burning Characteristics: Flame spread/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84, NFPA 255, or UL 723.

C. Source Limitations: Obtain insulation of each type through one source from a single manufacturer.

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

1.07 FIELD CONDITIONS
A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
B. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 PRODUCTS

2.01 FLEXIBLE GLASS FIBER INSULATION
A. Manufacturers: Subject to compliance with requirements, available manufacturers that may be incorporated into the work include, but are not limited to the following:
B. Insulation: ASTM C553; flexible, noncombustible blanket.
   1. 'K' value: 0.36 at 75 degrees F, when tested in accordance with ASTM C518.
   2. Maximum Service Temperature: 250 degrees F.
   3. Maximum Water Vapor Sorption: 5.0 percent by weight.
C. Vapor Barrier Jacket:
   1. Kraft paper with glass fiber yarn and bonded to aluminized film.
   2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96.
   3. Secure with pressure sensitive tape.
D. Vapor Barrier Tape:
   1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.

2.02 RIGID GLASS FIBER INSULATION
A. Manufacturers: Subject to compliance with requirements, available manufacturers that may be incorporated into the work include, but are not limited to the following:

B. Insulation: ASTM C612; rigid, noncombustible blanket.
   1. 'K' value: 0.24 at 75 degrees F, when tested in accordance with ASTM C518.
   2. Maximum service temperature: 450 degrees F.
   3. Maximum Water Vapor Sorption: 5.0 percent.

C. Vapor Barrier Jacket:
   1. Kraft paper with glass fiber yarn and bonded to aluminized film.
   2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96.
   3. Secure with pressure sensitive tape.

D. Vapor Barrier Tape:
   1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.

PART 3 EXECUTION

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

3.02 INSTALLATION
   A. Install in accordance with manufacturer's instructions.
   B. Install in accordance with NAIMA National Insulation Standards.
   C. Insulate all concealed supply air ducts where not lined. Insulate all concealed relief or exhaust air ducts within 10-ft of an exterior wall or roof opening. Liner will be installed within ducts where indicated, noted, or detailed.
   D. Insulated ducts conveying air above or below ambient temperature:
      1. Provide insulation with vapor barrier jackets.
      2. Finish with tape and vapor barrier jacket.
      3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
      4. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.
   E. Ducts Exposed Within Mechanical Rooms:
      1. Install rigid duct insulation as specified above only. No flexible insulation wrap.

3.03 SCHEDULES
   A. Outside Air Ducts:
      1. Rigid Glass Fiber Duct Insulation: 2 inches thick.
   B. Supply Air Ducts:
      1. Flexible Glass Fiber Duct Insulation: 1-1/2 inches thick.
C. Supply Ducts After Terminal Boxes:
   1. Flexible Glass Fiber Duct Insulation: 1 inches thick.
   2. Glass Fiber Duct Liner Insulation: 1 inches thick.

D. Return Air Ducts:
   1. Glass Fiber Duct Liner: 1 inches thick.

E. Exhaust Air Ducts:
   1. Flexible Glass Fiber Duct Insulation: 1-1/2 inches thick.

F. Ducts Within Mechanical Rooms:
   1. Rigid Glass Fiber Duct Insulation: 2 inches thick.

   END OF SECTION
PART 1 GENERAL

1.01 SECTION INCLUDES

A. Piping insulation.

B. Jackets and accessories.

1.02 RELATED REQUIREMENTS

A. Specifications throughout all divisions of the project manual are directly applicable to this section, and this section is directly applicable to them.

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this project, unless identified by a specific edition date. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this project.

B. American Society for Testing and Materials:

C. Underwriters Laboratories:

1.04 ACTION SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

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

C. Qualifications Statement: Submit name and qualifications of insulation applicator and name of supervisor for approval within 30-days after award of Contract.

1.05 QUALITY ASSURANCE

A. Applicator Qualifications: Company specializing in performing the type of work specified in this section, having a minimum of 5-years experience and approval of the manufacturer.

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

C. Source Limitations: Obtain insulation of each type through one source from a single manufacturer.
1.06 DELIVERY, STORAGE, AND HANDLING
A. Accept materials on site, labeled with manufacturer's identification, product density, and thickness.

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

PART 2 PRODUCTS

2.01 RIGID GLASS FIBER INSULATION
A. Manufacturers: Subject to compliance with requirements, available manufacturers that may be incorporated into the work include, but are not limited to the following:
5. Substitutions: See Section 20 0050 for substitution procedures.
B. Insulation: ASTM C547 and ASTM C795; rigid molded, noncombustible.
   1. 'K' value: ASTM C177, 0.24 at 75 degrees F.
   2. Maximum service temperature: 850 degrees F.
   3. Maximum moisture absorption: 0.2 percent by volume.
C. Vapor Barrier Jacket: White kraft paper with glass fiber yarn, bonded to aluminized film; moisture vapor transmission when tested in accordance with ASTM E96/E96M of 0.02 perm-inches.
D. Vapor Barrier Lap Adhesive: Compatible with insulation.
E. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.

2.02 FLEXIBLE ELASTOMERIC CELLULAR INSULATION
A. Manufacturer:
   1. Armacell: armacell.us.
   2. Substitutions: See Section 20 0050 for substitution procedures.
B. Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534 Grade 3; use molded tubular material wherever possible. AP Armaflex or approved equal.
   1. Minimum Service Temperature: Minus 40 degrees F.
   2. Maximum Service Temperature: 220 degrees F.
C. Adhesive: Manufacturer's recommended adhesive, compatible with insulation; AP Armaflex 520.
D. Finish: Manufacturer's recommended finish, compatible with insulation; AP Armaflex WB.
E. Fittings: Supply mfr's preformed flexible elastomeric fittings; no field fabricated fittings.
2.03 JACKETS

A. PVC or ABS Plastic.
   1. Jacket: One piece molded type fitting covers and sheet material, off-white color.
      a. Minimum Service Temperature: 0 degrees F.
      b. Maximum Service Temperature: 150 degrees F.
      c. Moisture Vapor Permeability: 0.002 perm inch, maximum, when tested in accordance with ASTM E96/E96M.
      d. Thickness: 10 mil.
      e. Connections: Pressure sensitive color matching vinyl tape.

   1. Thickness: 0.016 inch sheet.
   2. Finish: Smooth.
   4. Fittings: 0.016 inch thick die shaped fitting covers with factory attached protective liner.
   5. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that piping has been tested before applying insulation materials.

B. Verify that surfaces are clean and dry, with foreign material removed.

3.02 INSTALLATION

A. Install in accordance with NAIMA National Insulation Standards and manufacturer's instructions.

B. Glass fiber insulated pipes conveying fluids below ambient temperature:
   1. Provide vapor barrier jackets, factory-applied or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples and vapor barrier mastic.
   2. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Finish with PVC fitting covers.

C. Insulated pipes conveying fluids below ambient temperature: Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, etc.

D. Glass fiber insulated pipes conveying fluids above ambient temperature:
   1. Provide standard jackets, with or without vapor barrier, factory-applied or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples.
   2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.

E. Insulated pipes conveying fluids above ambient temperature and less than 140-deg F: Do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.

F. Insulated pipes conveying fluids above ambient temperature and greater than 140-deg F: Insulate entire system including fittings, valves, unions, flanges, strainers, etc.
G. Inserts and Shields:
   1. Shields: Piping 1/2-inch diameter or larger. Galvanized steel between pipe hangers and insulation. Tape all shields in place.
   2. Insert Application: Piping 2-inch diameter or larger when supported with hangers, 1/2-inch diameter or larger when strut mounted.
   3. Insert location: Between support shield and piping and under the finish jacket.
   4. Insert configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
   5. Insert material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.

H. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions. At fire separations, refer to Division 7.

I. Where piping is exposed, locate insulation and cover seams in the least visible locations. Cover all insulation with protective PVC or aluminum covers within 8-ft of the floor (or as noted).

J. Exterior Applications: Insulate fittings, joints, and valves with pre-formed insulation of like material and thickness as adjoining pipe. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

3.03 SCHEDULE

A. Heating Systems:
   1. Heating Water Supply and Return:
      a. Glass Fiber Insulation:
         1) Pipe Size Range: 2" and smaller.
         2) Thickness: 1 inch.
      b. Glass Fiber Insulation:
         1) Pipe Size Range: 2-1/2" thru 4".
         2) Thickness: 1-1/2 inch.
      c. Glass Fiber Insulation:
         1) Pipe Size Range: 5" and larger.
         2) Thickness: 2 inch.

B. Other Systems:
   1. Refrigerant Suction (and Liquid) Piping:
      a. Flexible Elastomeric Cellular Insulation:
         1) Pipe Size Range: All sizes.
         2) Thickness: 3/4 inch.

END OF SECTION
SECTION 23 2000
HYDRONIC PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Hydronic system requirements.
B. Heating water and chilled water piping, buried.
C. Heating water and chilled water piping, above grade.
D. Pipe hangers and supports.
E. Unions, flanges, couplings, and dielectric connections.
F. Ball valves.
G. Butterfly valves.
H. Check valves.
I. Balancing valves.

1.02 RELATED REQUIREMENTS

A. Specifications throughout all divisions of the project manual are directly applicable to this section, and this section is directly applicable to them.

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this project, unless identified by a specific edition date. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this project.
B. ASME (BPV IX) - Boiler and Pressure Vessel Code, Section IX - Welding and Brazing Qualifications; The American Society of Mechanical Engineers; 2010.
C. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300; The American Society of Mechanical Engineers; 2011.
D. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; The American Society of Mechanical Engineers; 2012 (ANSI B16.18).
E. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings; 2001 (R2010).
F. ASME B31.9 - Building Services Piping; 2011 (ANSI/ASME B31.9).
M. AWS A5.8/A5.8M - Specification for Filler Metals for Brazing and Braze Welding; 2011 and errata.
O. AWWA C606 - Grooved and Shouldered Joints; 2011 (ANSI/AWWA C606).

1.04 SUBMITTALS
A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
B. Product Data:
   1. Include data on pipe materials, pipe fittings, valves, and accessories.
   2. Provide manufacturers catalogue information.
   3. Indicate valve data and ratings.
   4. Piping must be clearly identified with intended service and range of sizes indicated.
   5. Valves and other accessories shall be identified to correspond with the piping submittals.
C. Project Record Documents: Record actual locations of valves.
D. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

1.05 QUALITY ASSURANCE
A. Installer Qualifications: Company specializing in performing work of the type specified in this section, with minimum five years of experience.
B. Welder Qualifications: Certify in accordance with ASME (BPV IX).

1.06 DELIVERY, STORAGE, AND HANDLING
A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
B. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
C. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 PRODUCTS

2.01 HYDRONIC SYSTEM REQUIREMENTS
A. Comply with ASME B31.9 and applicable federal, state, and local regulations.
B. Piping: Provide piping, fittings, hangers and supports as required, as indicated, and as follows:
1. Where more than one piping system material is specified, provide joining fittings that are compatible with piping materials and ensure that the integrity of the system is not jeopardized.
2. Use non-conducting dielectric connections whenever jointing dissimilar metals.
3. Grooved mechanical joints may be used in accessible locations only.
   a. Accessible locations include those exposed on interior of building, in pipe chases, and in mechanical rooms, aboveground outdoors, and as approved by Engineer.
   b. Grooved mechanical connections and joints comply with AWWA C606.
   c. Use rigid joints unless otherwise indicated.
4. Provide pipe hangers and supports in accordance with ASME B31.9 or MSS SP-58 unless indicated otherwise.

C. Pipe-to-Valve and Pipe-to-Equipment Connections: Use flanges, unions, or grooved couplings to allow disconnection of components for servicing; do not use direct welded, soldered, or threaded connections.
1. Where grooved joints are used in piping, provide grooved valve/equipment connections if available; if not available, provide flanged ends and grooved flange adapters.

D. Valves: Provide valves where indicated and as follows:
1. Provide drain valves at main shut-off, low points of piping, bases of vertical risers, and at equipment. Use 3/4 inch ball valves with cap; pipe to nearest floor drain.
2. For shut-off and to isolate parts of systems or vertical risers, use ball or butterfly valves.

2.02 HEATING WATER AND CHILLED WATER PIPING, BURIED

A. PRE-INSULATED THERMAL SINGLE and THERMAL TWIN PEX DISTRIBUTION SYSTEM MATERIALS
1. Service Tubing
   a. Material: Crosslinked polyethylene (PEX) manufactured to PEX-a or Engel-method standard
   b. Material Standard: Manufactured in accordance with ASTM F876 and F877
   c. Pressure Ratings: Hydrostatic design and pressure ratings are in accordance with the ASTM standard. Operating limits are as follows.
      1) -58 degrees F to 203 degrees F at 80 psi (-50 degrees C to 95 degrees C at 551 kPA)
   d. The PEX service tubing in the Ecoflex Thermal Single pipe has an oxygen diffusion barrier that does not exceed an oxygen diffusion rate of 0.10 grams per cubic meter per day at 104 degrees F (40 degrees C) water temperature in accordance with German DIN 4726.
   e. Nominal Inside Diameter: Provide tubing with nominal inside diameter in accordance with ASTM F876, as indicated. Note: Numbers in brackets are the metric equivalent pipe size.
      1) 1 inch [25mm]
      2) 1¼ inch [32mm]
      3) 1½ inch [40mm]
      4) 2 inch [50mm]
      5) 2½ inch [63mm]
      6) 3 inch [75mm]
      7) 3½ inch [90mm]
      8) 4 inch [110mm]
2. Outer Jacket
   a. Material is corrugated seamless high-density polyethylene (HDPE).
   b. The HDPE jacket completely encompasses and protects the insulation from moisture and damage.
   c. The outer jacket is extruded directly over the insulation and is flexible.
   d. The outer jacket shall contain 2 percent carbon black, finely divided and thoroughly dispersed to provide protection from UV degradation.

B. Minimum Bend Radius
   1. 1-inch pre-insulated tubing with 5.5-inch [140mm] jacket has a bend radius of 10 inches [254mm].
   2. 1¼-inch pre-insulated tubing with 5.5-inch [140mm] jacket has a bend radius of 12 inches [304mm].
   3. 1½-inch pre-insulated tubing with 6.9-inch [175mm] jacket has a bend radius of 16 inches [406mm].
   4. 2-inch pre-insulated tubing with 6.9-inch [175mm] jacket has a bend radius of 18 inches [457mm].
   5. 2½-inch pre-insulated tubing with 6.9-inch [175mm] jacket has a bend radius of 30 inches [762mm].
   6. 3-inch pre-insulated tubing with 7.9-inch [200mm] jacket has a bend radius of 32 inches [812mm].
   7. 3½-inch pre-insulated tubing with 7.9-inch [200mm] jacket has a bend radius of 44 inches [1117mm].
   8. 4-inch pre-insulated tubing with 7.9-inch [200mm] jacket has a bend radius of 48 inches [1219mm].

C. Insulation
   1. The insulation shall be layered, expanded cross-linked water-resistant polyethylene closed-cell foam.
   2. All seams of the insulation shall be sealed.
   3. Insulation shall not be bonded to the service tubing.

D. End Seals
   1. The piping manufacturer will supply all EPDM rubber end caps with water stop seal.
   2. EPDM rubber end caps are to be installed on each end prior to connecting the service pipes and insulating the field joints.
   3. The EPDM end caps will seal onto the tubing and outer jacket forming a watertight seal.

E. Cold Expansion Fittings for PEX-a Service Tubing
   1. For system compatibility, use fittings offered by the tubing manufacturer.
   2. Fittings must comply with the performance requirements of ASTM F877.
   3. Fittings are to be manufactured in accordance with ASTM F1960.
   4. The fitting assembly consists of a barbed adapter and appropriately sized PEX ring.
   5. All buried fittings will be installed, insulated, and sealed in accordance with the instructions of the piping manufacturer.

F. Compression Fittings for PEX Service Tubing
   1. For system compatibility, use fittings offered by the tubing manufacturer.
   2. Fittings are to be manufactured from dezincification-resistant brass.
   3. The fitting assembly must comply with performance requirements of ASTM F877.
   4. The fittings will consist of a compression fitting with a coupling sleeve, a fitting body insert with o-ring(s) and a bolt and nut.
5. All buried fittings will be installed, insulated, and sealed in accordance with the piping manufacturer's instructions.

6. Male NPT thread for each compression fitting is shown below.
   a. 1-inch PEX compression fitting has 1-inch male NPT thread.
   b. 1¼-inch PEX compression fitting has 1¼-inch male NPT thread.
   c. 1½-inch PEX compression fitting has 1½-inch male NPT thread.
   d. 2-inch PEX compression fitting has 2-inch male NPT thread.
   e. 2½-inch PEX compression fitting has 2-inch male NPT thread.
   f. 3-inch PEX compression fitting has 2½-inch male NPT thread.
   g. 3½-inch PEX compression fitting has 3-inch male NPT thread.
   h. 4-inch PEX compression fitting has 4-inch male NPT thread.

7. All transition fittings connecting to the compression fittings shall be manufactured of dezincification-resistant brass.

G. PIPE AND FITTING IDENTIFICATION
1. The pipe shall be marked in accordance with the standards to which it is manufactured.
2. Color identification by the use of stripes on pipe to identify pipe service shall be optional. If used, stripes or colored exterior pipe product shall be blue for potable water, green for wastewater/sewage, or purple for reclaimed water. [Optional]
3. Tracing wire shall be placed parallel and 18 inches above, but separate from, the pipe and shall be 10 AWG. [Specifier can change this to preferred material or method; all pipes should have a locatable methodology.]
4. Marking tape shall be approved by the engineer and placed between 12 and 18 inches above the crown of the pipe. [Optional]

H. ACCESSORIES
1. Use accessories associated with the installation of the pre-insulated PEX-a distribution piping system as recommended by or available from the manufacturer.
2. Insulation Kits
   a. Insulation kits will be manufactured of ABS shells or HDPE sleeves, will feature equal thickness of closed-cell PEX insulation as the pipe, and sealed watertight.
3. Connection Vaults
   a. The piping manufacturer will provide the connection vaults when required by the project construction.
   b. Connection vaults shall be constructed of rotationally molded composite polyethylene and PE foam, providing a structurally sound and thermally insulated chamber.
   c. Heat shrink seals as provided by the tubing manufacturer shall be installed to prevent introduction of water into the vault.

2.03 HEATING WATER AND CHILLED WATER PIPING, ABOVE GRADE
A. Steel Pipe: ASTM A53, Schedule 40, black, using one of the following joint types:
   1. Welded Joints: ASTM A234, wrought steel welding type fittings; AWS D1.1 welded.

B. Steel Pipe Sizes 12 Inch and Over: ASTM A53/A53M, 0.375 inch wall, black, using one of the following joint types:
   2. Grooved Joints: AWWA C606 grooved pipe, fittings of same material, and mechanical couplings.
C. Copper Tube: ASTM B88, Type M (C), drawn, using one of the following joint types:
      a. Solder: ASTM B32 lead-free solder, HB alloy (95-5 tin-antimony) or tin and silver.
      b. Braze: AWS A5.8 BCuP copper/silver alloy.
   2. Grooved Joints: AWWA C606 grooved tube, fittings of same material, and copper-tube-dimension mechanical couplings.
      a. Manufacturers:
         2) Substitutions: See Section 01 6000 - Product Requirements.

2.04 PIPE HANGERS AND SUPPORTS

A. Provide hangers and supports that comply with MSS SP-58. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.

B. Hangers for Pipe Sizes 1/2 to 2 Inch: Malleable iron, adjustable swivel, split ring.

C. Hangers for Pipe Sizes 2-1/2 to 5 Inch: Carbon steel, adjustable, clevis.

D. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Malleable iron, adjustable swivel, split ring.

E. Trapeze Hangers: Steel channels with welded spacers and hanger rods.

F. Wall Supports: Welded steel bracket and wrought steel clamp.

G. Vertical Support: Steel riser clamp.

H. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.

I. In grooved installations, use rigid couplings with offsetting angle-pattern bolt pads or with wedge shaped grooves in header piping to permit support and hanging in accordance with ASME B31.9.

J. All rigidly mounted domestic piping shall be secured to 12 gauge 1-5/8 inch slotted channel framing with insulated strut clamps.

2.05 UNIONS, FLANGES, MECHANICAL COUPLINGS, AND DIELECTRIC CONNECTIONS

A. Unions for Pipe 2 Inches and Under:
   1. Ferrous Piping: 150 psig malleable iron, threaded.
   2. Copper Pipe: Bronze, soldered joints.

B. Flanges for Pipe Over 2 Inches:
   1. Ferrous Piping: 150 psig forged steel, slip-on.
   2. Copper Piping: Bronze.
   3. Gaskets: 1/16 inch thick preformed neoprene.

C. Mechanical Couplings for Grooved and Shouldered Joints: Two or more curved housing segments with continuous key to engage pipe groove, circular C-profile gasket, and bolts to secure and compress gasket.
   1. Dimensions and Testing: In accordance with AWWA C606.
   2. Mechanical Couplings: Comply with ASTM F1476.
3. Housing Material: Ductile iron, galvanized complying with ASTM A536.
4. Gasket Material: EPDM suitable for operating temperature range from -30 degrees F to 230 degrees F.
5. Bolts and Nuts: Hot dipped galvanized or zinc-electroplated steel.
6. When pipe is field grooved, provide coupling manufacturer's grooving tools.
7. Manufacturers:
   a. Anvil International: www.anvilintl.com
   d. Substitutions: See Section 01 6000 - Product Requirements.

D. Dielectric Connections:
1. Waterways:
   a. Water impervious insulation barrier capable of limiting galvanic current to 1 percent of short circuit current in a corresponding bimetallic joint.
   b. Dry insulation barrier able to withstand 600 volt breakdown test.
   c. Construct of galvanized steel with threaded end connections to match connecting piping.
   d. Suitable for the required operating pressures and temperatures.
2. Flanges:
   a. Dielectric flanges with same pressure ratings as standard flanges.
   b. Water impervious insulation barrier capable of limiting galvanic current to 1 percent of short circuit current in a corresponding bimetallic joint.
   c. Dry insulation barrier able to withstand 600 volt breakdown test.
   d. Construct of galvanized steel with threaded end connections to match connecting piping.
   e. Suitable for the required operating pressures and temperatures.

2.06 BALL VALVES
A. Manufacturers:
   4. Substitutions: See Section 01 6000 - Product Requirements.

B. Up To 2 Inches:
   1. Bronze one piece body, chrome plated brass ball, teflon seats and stuffing box ring, lever handle with balancing stops, solder ends with union.

C. Over 2 Inches:
   1. Ductile iron body, chrome plated stainless steel ball, teflon seat and stuffing box seals, lever handle, flanged or grooved ends, rated to 800 psi.

2.07 BUTTERFLY VALVES
A. Manufacturers:
   4. Substitutions: See Section 01 6000 - Product Requirements.
B. Up To 2 Inches:
   1. Not permitted.

C. Over 2 Inches:
   1. Body: Cast or ductile iron with resilient replaceable EPDM seat, wafer, lug, or grooved ends, extended neck.
   2. Disc: Construct of aluminum bronze, chrome plated ductile iron, stainless steel, ductile iron with EPDM encapsulation, or Buna-N encapsulation.
   3. Stem: Stainless steel with stem offset from the centerline to provide full 360 degree circumferential setting.

2.08 CHECK VALVES

A. Manufacturers:
   1. Nibco, Inc: www.nibco.com
   3. Substitutions: See Section 01 6000 - Product Requirements.

B. Swing Type Check Valves:
   1. Up to 2 Inches: MSS SP-80, Class 125, bronze body and cap, bronze swing disc with rubber seat, solder ends.
   2. Over 2 Inches: MSS SP-71, Class 125, iron body, bronze swing disc, renewable disc seal and seat, flanged or grooved ends.

C. Spring Loaded Check Valves: Class 125, iron body, bronze trim, stainless steel springs, bronze disc, Buna N seals, wafer style ends.

2.09 BALANCING VALVES

A. Manufacturers:
   1. Tour & Anderson; Model STA: www.
   2. Armstrong; Model CBV: www.
   4. Substitutions: See Section 01 6000 - Product Requirements.

B. Construction: Class 125, Brass or bronze body with union on inlet , temperature and pressure test plug on inlet and outlet .

C. Calibration: Control flow within 5 percent of selected rating, over operating pressure range of 10 times minimum pressure required for control, maximum minimum pressure 3.5 psi.

D. Generally, install 1/2” valve sizes for specified flow rates of 1.5 gpm or less, 3/4" valve sizes for specified flow rates of 3.5 gpm or less, and line size valves for all other flow rates.

2.10 DRAIN VALVES

A. Drain valves shall be ball valves as specified herein or ball valves as part of an integral flange isolator product. All drain valves shall be fitted with American standard hose thread fittings and blind hose caps.
PART 3 EXECUTION

3.01 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
B. Prepare pipe for grooved mechanical joints as required by coupling manufacturer.
C. Remove scale and dirt on inside and outside before assembly.
D. Prepare piping connections to equipment using jointing system specified.
E. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.
F. After completion, fill, clean, and treat systems. Refer to Section 23 2500 for additional requirements.

3.02 INSTALLATION

A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
B. Install in accordance with manufacturer's instructions.
C. Install heating water and chilled water piping to ASME B31.9 requirements.
D. Provide non-conducting dielectric connections wherever jointing dissimilar metals.
E. Route piping in orderly manner, parallel to building structure, and maintain gradient.
F. Install piping to maintain headroom, conserve building space, and not to interfere with use of space.
G. Group piping whenever practical at common elevations.
H. Sleeve all piping passing through partitions, walls, and floors. Install escutcheons on exposed, finished side of penetrations.
I. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified Division 7.
J. Slope piping and arrange to drain at low points.
K. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
L. Grooved Joints:
   1. Install in accordance with the manufacturer's latest published installation instructions.
   2. Gaskets to be suitable for the intended service, molded, and produced by the coupling manufacturer.
M. Inserts:
   1. Provide inserts for placement in concrete formwork.
   2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
3. Install inserts to extend 1 inch above the finished floor elevation in plumbing chases and mechanical equipment rooms.
4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

N. Pipe Hangers and Supports:
1. Install in accordance with ASME B31.9.
2. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
3. Place hangers within 12 inches of each horizontal elbow.
4. Use hangers with 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
6. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
7. Prime coat exposed steel hangers and supports.
8. Provide hangers adjacent to motor driven equipment with vibration isolation.

O. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.

P. Provide galvanized hangers and supports and accessories in locations exterior to the building.

Q. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with Division 08.

R. Install valves with stems upright or horizontal, not inverted.

S. Plug all open ends of incomplete piping work prevent the entrance of dirt and debris.

T. Install all pipe mounted temperature control devices (thermowells, valves, flow meters, etc).

U. Provide drain valves at all equipment and coils, at all low spots in the systems, at the base of all risers, and on the downstream side of all section valves so any given section may be drained.

V. Below-grade Installation
1. Pre-insulated piping shall be installed in accordance with manufacturer’s recommendations and the details as shown on the contract drawings.
2. The system will be installed with the fewest number of underground joints as possible.
3. The system does not require expansion loops, expansion joints or compensators of any type.
4. An EPDM rubber end cap shall be applied at all terminations of the pre-insulated piping system, including all fitting locations, to form a watertight seal.
5. All buried fittings will be installed, insulated and sealed in accordance with the piping manufacturer’s instructions.
6. Connection Vaults or Insulation Kits are required for all below-grade installations.
7. Backfill
   a. The pre-insulated piping system will be backfilled with clean sand material.
      1) Minimum vertical distance from the bottom of the tubing to the trench floor is 4 inches [100mm].
      2) Minimum lateral distance from the side of the tubing to the trench wall is 6 inches [150mm].
      3) Install a minimum of 12 inches [300mm] of clean fill over the top of the pre-insulated piping.
b. The balance of the trench can be backfilled with native soil void of stone greater than 2 inches [50mm] in diameter.

8. FIELD QUALITY CONTROL
   a. Site Tests
      1) To ensure system integrity, pressure-test the tubing before and during backfilling.
      2) The service tubing will be air tested at 1½ times the operating pressure for a minimum of 1 hour prior to system burial.

3.03 FIELD QUALITY CONTROL
   A. All heating and chilled water piping systems shall be installed, examined, inspected, and tested in accordance with the requirements of ASME 31.9.
   B. System Pressure and Leak Test:
      1. All new, altered, extended, or replaced piping shall be tested hydrostatically at 100 psig for a period of not less than 6 hours. Isolate and protect all equipment not designed to withstand the test pressure.
      2. Repair any leaks that may occur and repeat the test procedure. No insulation shall be installed until piping has passed pressure testing.
      3. Prepare and submit separate reports for each test, complete with diagram or description of section tested and any corrective action taken.

3.04 SCHEDULES
   A. Heating Water Supply and Return Piping:
      1. Pipe Sizes Up to 2 Inches: Steel Pipe or Copper Tube
      2. Pipe Sizes Over 2 Inches: Steel Pipe
   B. Chilled Water Supply and Return Piping:
      1. Pipe Sizes Up to to 2 Inches: Steel Pipe or Copper Tube
      2. Pipe Sizes Over 2 Inches: Steel Pipe
   C. Hanger Spacing for Copper Tubing:
      1. 1/2 inch and 3/4 inch: Maximum span, 5 feet; minimum rod size, 1/4 inch.
      2. 1 inch and 1-1/4 inch: Maximum span, 6 feet; minimum rod size, 1/4 inch.
      3. 1-1/2 inch and 2 inch: Maximum span, 8 feet; minimum rod size, 3/8 inch.
   D. Hanger Spacing for Steel Piping:
      1. 1/2 inch, 3/4 inch, and 1 inch: Maximum span, 7 feet; minimum rod size, 1/4 inch.
      2. 1-1/4 inches: Maximum span, 8 feet; minimum rod size, 3/8 inch.
      3. 1-1/2 inches: Maximum span, 9 feet; minimum rod size, 3/8 inch.
      4. 2 inches: Maximum span, 10 feet; minimum rod size, 3/8 inch.
      5. 2-1/2 inches: Maximum span, 11 feet; minimum rod size, 3/8 inch.
      6. 3 inches: Maximum span, 12 feet; minimum rod size, 3/8 inch.
      7. 4 inches: Maximum span, 14 feet; minimum rod size, 1/2 inch.
      8. 6 inches: Maximum span, 17 feet; minimum rod size, 1/2 inch.

END OF SECTION
SECTION 23 3110
HVAC METAL DUCTWORK

PART 1 GENERAL

1.01 SECTION INCLUDES
   A. Rectangular ducts and fittings.
   B. Round ducts and fittings.
   C. Sheet metal materials.
   D. Internal duct liner.
   E. Sealants and gaskets.
   F. Hangers and supports.
   G. Duct leakage testing.

1.02 RELATED REQUIREMENTS
   A. Specifications throughout all divisions of the project manual are directly applicable to this section, and this section is directly applicable to them.

1.03 REFERENCE STANDARDS
   A. The latest published edition of a reference shall be applicable to this project, unless identified by a specific edition date. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this project.
   B. American Society of Civil Engineers:
   C. American Society for Testing and Materials:
      2. ASTM A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   D. North American Insulation Manufacturers Association:
      1. NAIMA AH124 - Fibrous Glass Duct Liner Standard.
   E. National Fire Protection Association:
2. NFPA 90B - Standard for the Installation of Warm Air Heating and Air Conditioning Systems.

F. Sheet Metal and Air-Conditioning Contractors National Association:
1. SMACNA (DCS) - HVAC Duct Construction Standards: Metal and Flexible.
2. SMACNA (KVS) - Kitchen Ventilation Systems and Food Service Equipment Fabrication & Installation Guidelines.
3. SMACNA (LEAK) - HVAC Air Duct Leakage Test Manual.

G. Underwriters Laboratories:
1. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors.

1.04 ACTION SUBMITTALS
A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
B. Product Data: For each type of the following products:
   1. Liners and adhesives.
   2. Sealants and gaskets.
C. Delegated-Design Submittal:
   1. Sheet metal thicknesses.
   2. Joint and seam construction and sealing.
   3. Reinforcement details and spacing.
   4. Materials, fabrication, assembly, and spacing of hangers and supports.

1.05 INFORMATIONAL SUBMITTALS
A. Test Reports: Indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate, following SMACNA (LEAK).

1.06 CLOSEOUT SUBMITTALS
A. Project Record Documents: Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

1.07 QUALITY ASSURANCE
A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA (DCS) and performance and design criteria indicated in this section.
B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA (DCS) and ASCE/SEI 7.
C. Duct Leakage Tests: Comply with SMACNA HVAC Air Duct Leakage Test Manual. Test 100% of all ducts with a pressure class of greater than 3-inch water gauge.
1.08 DELIVERY, STORAGE, AND HANDLING

A. Promptly inspect shipments to insure ductwork is undamaged and complies with the specification.
B. Protect ductwork by storing in durable, water-proof, above ground packaging. Do not store material on grade.
C. Protect ductwork from moisture, dirt, dust, construction debris, and foreign materials. Where end caps or packaging is provided, take precaution so protection remains in place and free from damage.
D. Ductwork shall be kept sealed and cleaned prior to and after installation. All ductwork not kept clean, in the opinion of the architect, will be replaced at no additional cost to the project.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

A. All ductwork shall be constructed to be free from vibration, chatter, objectionable noise or pulsations, and leakage under specified operation conditions.
B. Use material, weight, thickness, construction, support, and installation methods as outlined in the above listed SMACNA publications.
C. Duct pressure classification and sealing requirements shall be as specified herein. Where not indicated, follow requirements in SMACNA publications.
D. Duct sizes indicated on the drawings are net inside dimensions. Where sizes are not indicated, the duct segment size shall be equal to the largest duct segment to which it is attached.
E. Pressure Class Requirements:
   1. Variable Volume: Unless otherwise indicated, the pressure class for variable volume system ductwork upstream of the air terminal units shall be equal to the static pressure at the fan discharge, but not less than 4-inches water gauge.
   2. Constant Volume: Unless otherwise indicated, the pressure class for constant volume system ductwork shall be equal to the static pressure at the fan discharge, but not less than 2-inches water gauge.
   3. The minimum allowable pressure class for all other ductwork, positive or negative, is 2-inches water gauge.

2.02 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA (DCS) for materials involved, duct-support intervals, and other provisions, based on indicated static-pressure class, and sealing requirements stated herein.
B. Longitudinal Seams: Select seam types and fabricate according to SMACNA (DCS), Figure 2-2, "Rectangular Duct/Longitudinal Seams."
   1. Longitudinal seams shall be flat crimped Pittsburgh lock (SMACNA Type L1) with specified sealant applied over seams.
C. Transverse Joints: Select joint types and fabricate according to SMACNA (DCS), Figure 2-1, "Rectangular Duct/Transverse Joints."
   1. Transverse joints in ducts 24-inches and under on the longest side may be slip and drive type or flanged.
2. Transverse joints in ducts exposed to view and concealed ducts larger than 24-inches shall be flanged.

D. Branch Connections: Comply with SMACNA (DCS), Figure 4-6, "Branch Connections."
   1. Rectangular Main to Rectangular Branch: 45-degree entry.
   2. Rectangular Main to Round Branch: Conical spin-in or high-performance type.

E. Elbows: Comply with SMACNA (DCS), Figure 4-2, "Rectangular Elbows."
   1. Use radius throat, radius heel elbows (SMACNA Type RE 1) with a minimum centerline radius to width ratio of one and one half times.
   2. Where 1.5 radius elbows will not fit, use short radius elbows (SMACNA Type RE 3) with a minimum centerline radius to width ratio of one times and two radius proportional splitter vanes installed within.
   3. Where radius elbows will not fit or where shown on the drawings, use rectangular mitered elbows (SMACNA Type RE 2) with vanes complying with SMACNA (DCS), Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

F. Transitions, Offsets, and Other Duct Construction: Select types and fabricate according to SMACNA (DCS), Chapter 4, "Fittings and Other Construction."

2.03 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA (DCS), Chapter 3, "Round, Oval, and Flexible Duct," for materials involved, duct-support intervals, and other provisions, based on indicated static-pressure class, and sealing requirements stated herein.

B. Longitudinal Seams: Select seam types and fabricate according to SMACNA (DCS), Figure 3-2, "Round Duct Longitudinal Seams."
   1. All exposed round duct shall be spiral lock-seam (SMACNA Type RL1) with gored elbows. No snap-lock or longitudinal seams are permitted.

C. Transverse Joints: Select joint types and fabricate according to SMACNA (DCS), Figure 3-1, "Round Duct Transverse Joints."
   1. Use beaded sleeve joints (SMACNA Type RT1) with minimum 2-inch insertion length, or flanged joints (SMACNA Type RT2 or RT2A).
   2. Transverse joints in concealed ducts 24-inches and larger in diameter and exposed ducts 12-inches and larger in diameter shall be flanged.

D. Tees and Laterals: Select types and fabricate according to SMACNA (DCS), Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees."
   1. Use 45-degree lateral or combination taps. Where velocities are less than 1000 feet per minute, conical tees may also be used.
   2. Saddle taps are permitted in existing ducts only.

E. Elbows: Comply with SMACNA (DCS), Figure 3-4, "Round Duct Elbows."
   1. Use radius elbows with a minimum centerline radius to diameter ratio of one and one half times. Where 1.5 radius elbows will not fit and velocity is 1200 feet per minute or lower, use 1.0 radius elbows.
   2. Round elbows shall be welded, segmented type. Elbows 10-inches and smaller may be stamped. Adjustable elbows are not permitted.
2.04 SHEET METAL MATERIALS

A. General Requirements: Comply with SMACNA (DCS) 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 A653.
   2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A1008, with oiled, matte finish for exposed ducts.

D. Stainless-Steel Sheets: Comply with ASTM A 480, Type 304 or 316; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated.

E. Reinforcement Shapes and Plates: ASTM A36, steel plates, shapes, and bars; black and galvanized.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.05 DUCT LINER

A. Manufacturers: Subject to compliance with requirements, available manufacturers that may be incorporated into the work include, but are not limited to the following:
   5. Substitutions: See Section 20 0050 for substitution procedures.

B. Fibrous-Glass Duct Liner: Comply with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

C. Maximum Thermal Conductivity:
   1. Type I, Flexible: 0.27 at 75 deg F mean temperature.
   2. Type II, Rigid: 0.23 at 75 deg F mean temperature.

D. Water Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C916.

E. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating.

2.06 SEALANT AND GASKETS

A. General Requirements: Surface-burning characteristics for sealants and gaskets shall have a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723.

B. Joint and Seam Sealant: Water-based, indoor or outdoor service, water resistant, mold and mildew resistant, maximum 75 g/L VOC content, compatible with galvanized sheet steel, stainless steel, or aluminum sheets.

C. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
2.07 HANGERS AND SUPPORTS

A. Strap and Rod Sizes: Comply with SMACNA (DCS), Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

B. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

C. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.

D. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports: Galvanized-steel shapes and plates for galvanized steel ducts.

G. Channel Support System: Shop or field fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end.

H. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

PART 3 EXECUTION

3.01 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. All air distribution ductwork shall be fabricated, erected, and supported, in accordance with all applicable standards of SMACNA, where such standards do not conflict with NFPA 90A, and where class of construction equals or exceeds that noted herein.

C. Duct systems have been designed for metal ducts. Fibrous glass duct (duct board) may not be substituted for metal duct.

D. Install ducts with fewest possible joints. Install round and flat-oval ducts in maximum practical lengths.

E. Limit transition angles to 15-degrees diverging and 30-degrees converging (each side).

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1-inch, plus allowance for flanges and insulation thickness.

I. Route ducts to avoid passing through electrical equipment rooms and enclosures.
J. Install sheet metal flashing collars where ducts are exposed to view (including mechanical rooms) and where ducts pass thru walls, floors, or ceilings.

K. All ductwork, including low pressure ductwork, shall be sealed to SMACNA Seal Class A with all joints, seams, and penetrations sealed, unless otherwise indicated.

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

M. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer.

N. Rectangular supply air ducts exposed above partial "cloud" ceilings shall be lined instead of insulated. Also, install liner within all ducts where indicated, noted, or detailed.

O. This contractor shall provide an appropriately sized wood frame "window-buck" to the mason for each masonry penetration with location dimensions permanently indicated.

P. This contractor will be responsible for installing all automatic control dampers and other devices furnished by the BAS contractor. See the BAS specifications for installation requirements.

3.02 FLEXIBLE CONNECTIONS

A. Connections to inlet and discharge openings of fans shall be made with a section of at least 1/16-inch thick neoprene coated fiberglass fabric. Flex connections shall not be less than 3-inches long and shall have at least 1-inch of slack.

B. Connections shall have angle frames at each end for rectangular ducts, and metal tension bands at each end for round ducts.

C. Connections shall be installed on straight duct sections, not transitional fittings, and allow for easy replacement.

D. Connections to units that have internally isolated fans within the unit housing will not require flex connections, unless otherwise indicated.

3.03 APPLICATION OF DUCT LINER

A. Factory or Shop Application of Duct Liner: Comply with SMACNA (DCS), Figure 7-11, "Flexible Duct Liner Installation."

B. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.

C. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.

D. Butt transverse joints without gaps, and coat joint with adhesive.

E. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.

F. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
G. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.

H. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or “z” profiles or are integrally formed from duct wall. Fabricate edge facings at fan discharges, and intervals of lined duct preceding unlined duct.

I. Terminate inner ducts with build-outs attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated build-outs (metal hat sections) or other build-out means are optional; when used, secure build-outs to duct walls with bolts, screws, rivets, or welds.

3.04 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Utilize flange connection systems with corner clips or optional nuts and bolts. Install in strict accordance with manufacturer’s instructions.

C. Trim duct gaskets and sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

D. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter.

E. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

F. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.05 WATER-TIGHT DUCTWORK

A. Where water or snow may accumulate in ductwork and plenums, ducts shall be made water-tight by soldering, brazing, or welding of joints and seams.

B. Install ductwork sloped down toward drain points at louver. Work with the general contractor to install flashing for a permanent water-tight seal.

C. Install duct drains and piping where indicated. Route drain piping at right angles around the perimeter of the room to a floor drain. Do not run piping across walkways or access.

D. Applies to dishwasher hood exhaust ductwork and air intake plenums.

3.06 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA (DCS), Chapter 5, “Hangers and Supports.”

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   1. Where practical, install concrete inserts before placing concrete.
   2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
   3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
   4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
C. **Hanger Spacing:** Comply with SMACNA (DCS), Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. **All supports shall be from joists, beams, or other structural members.** Do not support from roof decking. Install channel framing to span bar joists.

E. **Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at maximum intervals of 16 feet.**

F. **Install upper attachments to structures.** Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

G. **Straps may be used to support rectangular ducts 60-inches wide or smaller. Use trapeze hangers with rods and angles or channel to support rectangular duct larger than 60-inches wide.**

H. **Hangers Exposed to View:** Threaded rod and angle or channel supports.

I. **Use double nuts and lock washers on threaded rod supports.**

### 3.07 DUCT LEAKAGE TESTING

A. **Testing equipment, procedure and reports shall be in accordance with the latest edition of the SMACNA HVAC Air Duct Leakage Manual.**
   1. Equipment shall include, but not be limited to, a blower with volume control, manometer, and orifice meter with pressure differential manometer.
   2. Ductwork shall be tested in partial segments as work progresses before concealment and application of external insulation.
   3. Manometer readings shall be converted to cubic feet per minute from a calibrated test curve.

B. **The following ducts shall be tested:**
   1. Supply air ducts with a pressure classification of greater than 3-inches water gauge shall be tested with a leakage classification as scheduled herein.
   2. Test duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.

C. **Design pressure for testing ductwork shall be determined from the maximum pressure generated at the fan discharge at the nominal motor horsepower installed or the stated pressure class, whichever is greater.**

D. **Leaks identified during inspection or testing shall be repaired.**
   1. All leaks shall be found audibly or visually with smoke.
   2. All leaks shall be repaired or the joints remade, and testing repeated until acceptable results are achieved.
   3. Leaks shall be repaired by complete removal of the sealant materials, thorough cleaning of the joint surfaces, and reinstallation of multiple layers of sealing materials.

E. **All low pressure duct systems, positive or negative, shall be inspected for visual and audible signs of leakage.**

F. **Leaks that cause objectionable noise in the opinion of the Owner or engineer, must be repaired regardless of the amount of leakage.**
G. The contractor shall notify the design team 7-days in advance of when duct pressure testing is planned so the Owner or engineer has the option to observe the tests.

3.08 DUCT CLEANING

A. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.

B. Ductwork shall be kept sealed and cleaned prior to and after installation. All ductwork not kept clean, in the opinion of the architect, will be replaced at no additional cost to the project.

C. Clean the following components by removing surface contaminants and deposits:
   1. Air outlets and inlets (registers, grilles, and diffusers).
   2. Supply, return, and exhaust fans including fan housings, plenums, scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
   3. Air-handling unit internal surfaces and components including mixing box, coil section, condensate drain pans, filters and filter sections, and drains.

3.09 DUCT SCHEDULE

A. Primary Supply Air Ducts (upstream of variable volume terminal units):
   2. Pressure Class: Positive 4-inches water gauge.
   4. Leakage Class: 4 rectangular, 2 round.

B. Secondary Supply Air Ducts (downstream of variable volume terminal units):
   1. Pressure Class: Positive 2-inches water gauge.
   2. Seal Class: A, all joints, seams, and penetrations sealed.

C. Low Pressure Supply Air Ducts (single zone constant and variable volume systems):
   1. Pressure Class: Positive 2-inches water gauge.
   2. Seal Class: A, all joints, seams, and penetrations sealed.

D. Return Air and Outdoor Air Ducts:
   1. Pressure Class: Negative 2-inches water gauge.
   2. Seal Class: A, all joints, seams, and penetrations sealed.

E. Exhaust Air and Relief Air Ducts:
   1. Pressure Class: 2-inches water gauge, positive or negative.
   2. Seal Class: A, all joints, seams, and penetrations sealed.

F. Intermediate Reinforcement:
   1. Galvanized-Steel Ducts: Galvanized steel or carbon steel coated with zinc-chromate primer.

G. Liner:
   1. All Ducts: Fibrous glass, Type I, 1-inch thick, where indicated.

END OF SECTION
SECTION 23 3300
HVAC DUCT ACCESSORIES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Duct access doors.
B. Insulated flexible duct.
C. Flexible connections.
D. Branch connections.
E. Volume control dampers.
F. Turning vanes.
G. Pipe portal systems.

1.02 RELATED REQUIREMENTS

A. Specifications throughout all divisions of the project manual are directly applicable to this section, and this section is directly applicable to them.

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this project, unless identified by a specific edition date. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this project.

B. National Fire Protection Association:

C. Sheet Metal and Air-Conditioning Contractors National Association:
   1. SMACNA (DCS) - HVAC Duct Construction Standards.

D. Underwriters Laboratories:
   1. UL 33 - Heat Responsive Links for Fire-Protection Service.

1.04 ACTION SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide for shop fabricated assemblies including volume control dampers. Include electrical characteristics and connection requirements.

1.05 CLOSEOUT SUBMITTALS

A. Project Record Drawings: Record actual locations of access doors and test holes.
B. Operation and Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views, etc.

1.06 QUALITY ASSURANCE

A. Electrical Components: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Accept specialties on site in original factory packaging. Inspect for damage.

B. Protect dampers from damage to operating linkages and blades.

PART 2 PRODUCTS

2.01 DUCT ACCESS DOORS

A. Manufacturers:
   4. Substitutions: See Section 20 0050 for substitution procedures.

B. Fabrication: Rigid and close-fitting of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ducts, install minimum 1 inch thick insulation with sheet metal cover.
   1. Less Than 12 inches Square: Secure with sash locks.
   2. Up to 18 inches Square: Provide two hinges and two sash locks.
   3. Up to 24 x 48 inches: Three hinges and two compression latches.
   4. Larger Sizes: Provide an additional hinge.

C. Access doors with sheet metal screw fasteners are not acceptable.

2.02 INSULATED FLEXIBLE DUCT

A. Manufacturers:
   1. Hart and Cooley: hartandcooley.com
   2. Thermaflex: thermaflex.net
   3. Substitutions: See Section 20 0050 for substitution procedures.

B. Fabrication: UL 181, Class 1, two-ply vinyl or black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene or aluminized vapor-barrier film.

2.03 FLEXIBLE DUCT CONNECTIONS

A. Manufacturers:
   3. Substitutions: See Section 20 0050 for substitution procedures.

B. Fabrication: In accordance with SMACNA (DCS) and as indicated.
C. Flexible Duct Connections: Fabric crimped into metal edging strip.
   1. Fabric: UL listed fire-retardant neoprene coated woven glass fiber fabric to NFPA 90A, minimum density 30 oz per sq yd, approximately 2 inches wide.
   2. Metal: 3 inches wide, 24 gage, 0.0239 inch thick galvanized steel.

2.04 BRANCH CONNECTIONS

A. Manufacturers:
   2. Substitutions: See Section 20 0050 for substitution procedures.

B. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.

C. Rectangular sheet metal branch duct take-offs shall be fabricated with 45 degree entry fittings in accordance with SMACNA standards. Branch ducts shall include opposed action type multi-blade dampers where indicated on the drawings.

D. Sheet metal take-offs between rectangular and round ductwork shall be with conical bell-mouth type spin-ins, where duct sizes permit. Each fitting shall have a single blade quadrant locking damper as an integral part of the fitting. Fittings shall be Hercules bell-mouth spin-in, Hercules high efficiency take-off, or equivalent.

2.05 VOLUME DAMPERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers that may be incorporated into the work include, but are not limited to the following:
   2. Substitutions: See Section 20 0050 for substitution procedures.

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

C. Single Blade Dampers: Fabricate for duct sizes up to 6 x 30 inch.
   1. Blade: 24 gage, 0.0239 inch, minimum.

D. Multi-Blade Damper: Fabricate of opposed blade pattern with maximum blade sizes 8 x 72 inch. Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.
   1. Blade: 18 gage, 0.0478 inch, minimum.

E. End Bearings: Except in round ducts 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon, thermoplastic elastomer, or sintered bronze bearings.

F. Quadrants:
   1. Provide locking, indicating quadrant regulators on single and multi-blade dampers.
   2. On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.

2.06 TURNING VANES

A. Manufacturers:
3. Substitutions: See Section 20 0050 for substitution procedures.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.07 MISCELLANEOUS PRODUCTS

A. Pipe Portal Systems:
   1. Pipe portal system shall include an 18 gauge galvanized roof curb with integral base plate, continuously welded corner seams, factory-installed wood nailer, and 1-1/2 inch rigid fiberglass insulation.
   2. An EPDM compression molded cap shall be utilized. All caps shall include stainless steel snaplock clamps.
   3. Attachment and installation of the pipe portal shall be done in accordance with the manufacturer's instructions and the roofing membrane manufacturer's instructions.
   4. Products: Subject to compliance with requirements, available manufacturers that may be incorporated into the work include, but are not limited to the following:
      a. Portals Plus, Inc: commercialproducts group.com
      b. Substitutions: See Section 20 0050 for substitution procedures.

B. Equipment Support Rails:
   1. Equipment rails shall be fabricated of 18 gauge galvanized steel with built-in cant, monolithic construction with integral base plate and continuous mitered and welded corner seams, with factory installed wood 2x4 nailer.
   2. Each equipment rail shall include a matching 18 gauge galvanized steel counter-flashing cap with integral drip edge, all corners mitered and welded, with screws for attachment.
   3. Equipment rails over 3 feet long shall incorporate 14 gauge internal gussett reinforcing. Rail height to provide 6" clearance above the final roof surface, with a vertical step at the bottom (contractor verified) for insulation thickness.
   4. Products: Subject to compliance with requirements, available manufacturers that may be incorporated into the work include, but are not limited to the following:
      a. Roof Products and Systems: commercialproductsgroup.com
      b. Substitutions: See Section 20 0050 for substitution procedures.

PART 3 EXECUTION

3.01 PREPARATION

A. Verify that electric power is available and of the correct characteristics.

3.02 DUCT INSTALLATION

A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

B. Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA HVAC Duct Construction Standards. Refer to the Ductwork section for duct construction and pressure class.

C. Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, combination fire and smoke dampers, and elsewhere as indicated. Provide minimum 8 x 8 inch size for hand access, 18 x 18 inch size for shoulder
access, and as indicated. Provide 4 x 4 inch for balancing dampers only. Review locations prior to fabrication.

D. Provide duct test holes where indicated and required for testing and balancing purposes.

E. At fans and motorized equipment associated with ducts, provide flexible duct connections immediately adjacent to the equipment.

F. At equipment supported by vibration isolators, provide flexible duct connections immediately adjacent to the equipment.

G. Provide balancing dampers at points on supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Install minimum 2 duct widths from duct take-off.

3.03 FLEX DUCT INSTALLATION

A. Install insulated flexible ducts in accordance with SMACNA (DCS).

B. Support with bands 1-1/2" wide and spaced a maximum of 48-inches apart. Maximum centerline sag between supports shall not exceed 1/2-inch per 12-inches.

C. Do not bend flexible ducts across sharp corners, and avoid contact with fixtures, water lines, and conduits.

D. Install fully extended, in a direct line, without sags, twists, or turns. Bends shall not be less than one duct diameter.

E. Connect to diffusers and metal ducts with maximum 60-inch lengths of flexible ducts clamped or strapped in place.
   1. Tape the inner liner to the hard duct or device collar.
   2. Attach two nylon straps; one on the inner liner and one for the outer shell.
   3. Fold the outer shell inside itself before wrapping the hard duct.
   4. Install hard duct elbows at diffusers or “flexflow” radius forming elbows.

END OF SECTION
SECTION 23 3423
HVAC POWER VENTILATORS

PART 1 GENERAL

1.01 SECTION INCLUDES
   A. Inline centrifugal fans.

1.02 REFERENCE STANDARDS
   A. AMCA (DIR) - (Directory of) Products Licensed Under AMCA International Certified Ratings Program; 2015.
   C. AMCA 204 - Balance Quality and Vibration Levels for Fans; 2005 (Reaffirmed 2012).
   F. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data; 2014.

PART 2 PRODUCTS

2.01 POWER VENTILATORS - GENERAL
   A. Static and Dynamically Balanced: AMCA 204 - Balance Quality and Vibration Levels for Fans.
   B. Performance Ratings: Determined in accordance with AMCA 210 and bearing the AMCA Certified Rating Seal.
   C. Sound Ratings: AMCA 301, tested to AMCA 300 and bearing AMCA Certified Sound Rating Seal.
   D. Fabrication: Comply with AMCA 99.
   E. Electrical Components: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

2.02 INLINE CENTRIFUGAL FANS
   A. Centrifugal Fan Unit: V-belt or direct driven with galvanized steel housing lined with acoustic insulation, resilient mounted motor, gravity backdraft damper in discharge.
   B. Disconnect Switch: Cord and plug in housing for thermal overload protected motor and wall mounted switch.
   C. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheaves selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.
PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

END OF SECTION
SECTION 23 3710
GRILLES REGISTERS AND DIFFUSERS

PART 1 GENERAL

1.01 SECTION INCLUDES
A. Grilles, registers, and diffusers.

1.02 RELATED REQUIREMENTS
A. Specifications throughout all divisions of the project manual are directly applicable to this section, and this section is directly applicable to them.

1.03 REFERENCE STANDARDS
A. The latest published edition of a reference shall be applicable to this project, unless identified by a specific edition date. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this project.
B. American Society of Heating, Refrigeration, and Air-Conditioning Engineers:
   1. ASHRAE Std 70 - Method of Testing the Performance of Air Outlets and Inlets.
C. Sheet Metal and Air Conditioning Contractors' National Association:
   1. SMACNA (DCS) - HVAC Duct Construction Standards.

1.04 ACTION SUBMITTALS
A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.
   1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
   2. Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2 PRODUCTS

2.01 MANUFACTURERS
A. Subject to compliance with requirements, provide basis of design products indicated on the drawings or comparable products by one of the following:
   3. Metal-Aire: metalindustries.com
   4. Substitutions: See Section 20 0050 for substitution procedures.

2.02 RECTANGULAR CEILING DIFFUSERS
A. Type: Provide square and rectangular, multi-louvered diffuser to discharge air in two way and four way pattern.
B. Connections: As scheduled on drawings.

C. Frame: Provide surface mount and inverted T-bar type. In plaster ceilings, provide plaster frame and ceiling frame.

D. Fabrication: Aluminum with baked enamel finish.

E. Color: As shown on drawings.

2.03 CEILING AND DUCT SLOT DIFFUSERS

A. Type: Continuous width slot with adjustable vanes for left, right, or vertical discharge. Number of slots and width scheduled on the drawings.

B. Fabrication: Aluminum extrusions with factory clear lacquer finish.

C. Color: As shown on the drawings.

D. Frame: 1-1/4 inch margin with countersunk screw mounting and gasket, mitered end border.

E. Plenum: Integral, galvanized steel, insulated.

2.04 SURFACE SUPPLY REGISTERS/GRILLES

A. Type: Streamlined and individually adjustable blades to discharge air along face of grille, two-way deflection.

B. Frame: 1 inch margin with countersunk screw mounting and gasket.

C. Fabrication: Aluminum extrusions with factory enamel finish.

D. Color: As shown on drawings.

E. Damper: Where scheduled, integral, gang-operated, opposed blade type with removable key operator, operable from face.

2.05 EXHAUST AND RETURN REGISTERS/GRILLES

A. Type: Streamlined blades, 3/4 inch minimum depth, 3/4 inch maximum spacing, with blades set at 45 degrees, vertical face.

B. Fabrication: Steel and aluminum with 20 gauge minimum frame, or aluminum extrusions, with factory enamel finish.

C. Frame: 1 inch margin with countersunk screw mounting.

D. Color: As shown on the drawings.

E. Damper: Where scheduled, integral, gang-operated, opposed blade type with removable key operator, operable from face.

2.06 CEILING EGG CRATE EXHAUST AND RETURN GRILLES

A. Type: Egg crate style face consisting of 1/2 x 1/2 x 1/2-inch grid core.

B. Fabrication: Grid core consists of aluminum with baked enamel finish.
C. Color: As shown on the drawings
D. Frame: 1-1/4 inch margin with countersunk screw mounting.
E. Frame: Channel lay-in frame for suspended grid ceilings.

PART 3 EXECUTION

3.01 INSTALLATION
A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
B. Install in accordance with manufacturer's instructions. Install level and plumb.
C. Ceiling-Mounted Outlets and Inlets:
   1. Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop.
   2. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel.
   3. Make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.
D. Install diffusers with airtight connections to ducts and to allow service and maintenance of dampers, extractors, and fire dampers.
E. After installation, adjust diffusers, grilles, and registers to air patterns indicated, or as directed, before starting air balancing.
F. Provide balancing dampers on duct take-off to diffusers, grilles, and registers, where dampers are not specified as part of the air device assembly.
G. Paint ductwork visible behind air outlets and inlets matte black.

3.02 SCHEDULES
A. See equipment schedules on the drawings for Basis of Design.

END OF SECTION
PART 1 GENERAL

1.01 SECTION INCLUDES

A. Louvers.
B. Roof hoods.

1.02 RELATED REQUIREMENTS

A. Specifications throughout all divisions of the project manual are directly applicable to this section, and this section is directly applicable to them.

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this project, unless identified by a specific edition date. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this project.
B. Air Movement and Control Association International:
   1. AMCA 500-L - Laboratory Methods of Testing Louvers for Rating.
C. Sheet Metal and Air Conditioning Contractors National Association:
   1. SMACNA (DCS) - HVAC Duct Construction Standards.

1.04 ACTION SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.
   1. Show frame profiles and blade profiles, angles, and spacing.
   2. Show mullion profiles and locations where applicable.
   3. Include plans, elevations, sections, details, and attachments to other work.
   4. For louvers include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.
C. Samples: Color samples for initial selection for equipment with factory applied color finishes.

1.05 FIELD CONDITIONS

A. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication.
B. Coordination: Coordinate sizes and locations of roof curbs, equipment supports, and building penetrations with actual equipment provided.
PART 2 PRODUCTS

2.01 FIXED EXTRUDED ALUMINUM LOUVERS

A. Manufacturers: Subject to compliance with requirements, provide basis of design products indicated on the drawings or comparable products by one of the following:
   1. Ruskin Company: ruskin.com
   3. Substitutions: See Section 20 0050 for substitution procedures.

B. Type: Horizontal drainable-blade louver, 4-inch or 6-inch deep, blades on 37.5-deg or 45-deg slope, with square mesh bird screen.

C. Fabrication: Minimum 12-gauge thick extruded aluminum, welded assembly with factory finish.

D. Frame: Standard channel frame construction, or integral flanged as scheduled on the drawings.

E. Finish: Anodized mill finish, baked enamel, or prime coat as scheduled on the drawings.

F. Color: To be selected by Architect from manufacturers standard range.

G. Bird Screen: 16-gauge, 1/2-inch, expanded flattened aluminum with removable frame.

H. Gutters: Drain gutters in head frame and each blade.

I. Downspouts: Downspouts in jambs to drain water away from louver.

J. Supports: Hidden vertical supports to allow continuous line appearance.

K. Sill: Steeply angled integral sill to eliminate standing or trapped moisture. Provide extended sills for recessed louvers.

2.02 GRAVITY VENTILATORS

A. Manufacturers: Subject to compliance with requirements, provide basis of design products indicated on the drawings or comparable products by one of the following:
   1. Loren Cook Company: lorencook.com

B. Type: Low-profile, rectangular, formed aluminum gravity ventilator, cross-broke roof cap, chamfered roof ends, mill finish, with hinged base, and square mesh bird screen.

C. Fabrication: Minimum 12-gauge thick extruded aluminum cap, welded assembly with factory finish. Aluminum throat, extruded aluminum angle corner bracing, and extruded aluminum channel interior bracing.

D. Assembly: Integral base flange, mechanically fastened, solid welded thru-out, with liquid seal welded curb cap joints.

E. Bird Screen: Galvanized-steel or aluminum, 1/2-inch square mesh, with removable frame.

F. Damper: Where indicated, heavy gauge aluminum frame, 24-gauge aluminum blades, aluminum hinge pins, and brass bushings.

G. Roof Curb: Galvanized steel; mitered and continuously welded corners with mounting flange; 1-1/2-inch rigid fiberglass insulation; 1-1/2-inch wood nailor; with damper tray where applicable.
1. Finished curb height shall be 12-inches, unless indicated otherwise.
2. Coordinate roof pitch and overall height with roof deck construction.

H. Make hood area equal to throat area for exhaust applications; twice throat area for intake applications.

PART 3 EXECUTION

3.01 INSTALLATION

A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

B. Install at locations indicated in accordance with manufacturer's instructions. Verify dimensions of openings.

C. Install louvers plumb, level, in the plane of the wall, and in alignment with adjacent work.

D. Slope ductwork to drain toward louvers and connect with a water tight seal.

E. Coordinate louver installation with installation of flashing by others.

F. Install gravity ventilators plumb, level, and at indicated alignment with adjacent work.

G. Install roof curbs so top surface is level. Anchor securely to the roof deck to resist loads.

H. Install perimeter reveals and openings of uniform width for sealants and joint fillers.

I. Install concealed gaskets, flashings, joint fillers, sealants, and insulation for weather-tight joints as installation progresses. Install joint sealants as specified by Architect.

J. Verify that dampers operate properly with unrestricted airflow. Clean, lubricate, and adjust operating mechanisms.

3.02 SCHEDULES

A. See equipment schedules on the drawings for Basis of Design.

END OF SECTION
SECTION 23 7313
MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES
A. Casing construction.
B. Fan section.
C. Coil section.
D. Filter and air cleaner section.
E. Damper section.
F. Access section.

1.02 REFERENCE STANDARDS
A. ABMA STD 9 - Load Ratings and Fatigue Life for Ball Bearings; 2015.
C. AMCA (DIR) - (Directory of) Products Licensed Under AMCA International Certified Ratings Program; 2015.
G. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data; 2014.
J. ASHRAE Std 62.1 - Ventilation for Acceptable Indoor Air Quality; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
K. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
M. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2005 (Revised 2009).

1.03 ADMINISTRATIVE REQUIREMENTS
A. Coordinate the work with other trades for installation of roof mounted air handling units on roof curbs.
B. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.
1.04 SUBMITTALS

A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

B. Product Data:
   1. Published Literature: Indicate dimensions, weights, capacities, ratings, gauges and finishes of materials, and electrical characteristics and connection requirements.
   2. Filters: Data for filter media, filter performance data, filter assembly, and filter frames.
   3. Fans: Performance and fan curves with specified operating point clearly plotted, power, RPM.
   4. Sound Power Level Data: Fan outlet and casing radiation at rated capacity.
   5. Electrical Requirements: Power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.

C. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.

1.05 QUALITY ASSURANCE

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

1.06 DELIVERY, STORAGE, AND HANDLING

A. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.

B. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

C. Do not operate units until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

PART 2 PRODUCTS

2.01 MANUFACTURERS


2.02 CASING CONSTRUCTION

A. Full Perimeter Base Rail:
   2. Provide base rail of sufficient height to raise unit for external trapping of condensate drain pans.

B. Casing:
   1. Construct of one piece, insulated, double wall panels.
   2. Provide mid-span, no through metal, internal thermal break.
   3. Construct outer panels of galvanized steel and inner panels of galvanized steel.
4. Casing Air Pressure Performance Requirements:
   a. Able to withstand up to 8 inches w.g. positive or negative static pressure.
   b. Not to exceed 0.0042 inches per inch deflection at 1.5 times design static pressure up to a maximum of plus 8 inches w.g. in positive pressure sections and minus 8 inches w.g. in negative pressure sections.

C. Access Doors:
   1. Construction, thermal and air pressure performance same as casing.
   2. Provide surface mounted handles on hinged, swing doors.

D. Outside Air and Exhaust Air Weather Hood:
   1. Fabricate from same material as casing outer panel.
   2. Extend hood past perimeter of unit casing opening so as not to instruct airflow path.
   3. Paint hoods with same finish as external surface of outdoor units.
   4. Provide inlet hood for each fresh air damper with a sine wave moisture eliminator to prevent entrainment of water into the unit from outside air.
   5. Provide exhaust hoods for each exhaust air opening.
   6. Size each hood for 100 percent of nominal fresh air damper capacities.
   7. Protect each hood with bird screen to prevent nesting at intake or exhaust air flow paths.

E. Unit Flooring: Construct with sufficient strength to support expected people and equipment loads associated with maintenance activities.

F. Casing Leakage: Seal joints and provide airtight access doors so that air leakage does not exceed one percent of design flow at the specified casing pressure.

G. Insulation:
   1. Provide minimum thermal thickness of 12 R throughout.
   2. Completely fill panel cavities in each direction to prevent voids and settling.
   3. Comply with NFPA 90A.

H. Drain Pan Construction:
   1. Provide cooling coil and humidifier sections with an insulated, double wall, galvanized steel drain pan complying with ASHRAE Std 62.1 for indoor air quality and sufficiently sized to collect all condensate.
   2. Slope in two planes to promote positive drainage and eliminate stagnate water conditions.
   3. Locate outlet of sufficient diameter at lowest point of pan to prevent overflow at normal operating conditions.
   4. Provide threaded drain connections constructed of drain pan material, extended sufficient distance beyond the base to accommodate field installed, condensate drain trapping.

I. Louvers: Stationary, of galvanized steel, 4 inch deep with plenum, nylon bearings, 1/2 inch mesh, 0.04 inch galvanized wire bird screen in aluminum frame, and bearing AMCA Certified Ratings Seal in accordance with AMCA 500-L. Furnish adjustable louvers with hollow vinyl bulb edging on blades and foam side stops to limit leakage to maximum 2 percent at 4 inch wg differential pressure when sized for 2000 fpm face velocity.

J. Finish:

2.03 FAN SECTION

A. Type: Backward inclined, single width, single inlet, centrifugal plug type fan, in compliance with AMCA 99. Refer to Section 23 3413.
B. Performance Ratings: Determined in accordance with AMCA 210 and labeled with AMCA Certified Rating Seal.

C. Sound Ratings: AMCA 301; tested to AMCA 300 and label with AMCA Certified Sound Rating Seal.

D. Bearings: Self-aligning, grease lubricated, with lubrication fittings extended to exterior of casing with plastic tube and grease fitting rigidly attached to casing.

E. External Motor Junction Box: Factory mount NEMA 4 external junction box and connect to extended motor leads from internally mounted motors.

F. Motor Wiring Conduit: Factory wire fan motor wiring to the unit mounted variable frequency drive and external motor junction box.

G. Fan Accessories:

H. Flexible Duct Connections:
   1. For separating fan, coil, and adjacent sections.

I. Drives:
   2. Bearings: Heavy duty pillow block type, ball bearings, with ABMA STD 9, L-10 life at 50,000 hours.
   3. Shafts: Solid, hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.
   4. V-Belt Drive: Cast iron or steel sheaves, dynamically balanced, bored to fit shafts, and keyed. Variable and adjustable pitch sheaves for motors 15 hp and under selected so required rpm is obtained with sheaves set at mid-position; fixed sheave for 20 hp and over, matched belts, and drive rated as recommended by manufacturer or minimum 1.5 times nameplate rating of the motor.
   5. Belt Guard: Fabricate to SMACNA (DCS); 0.106 inch thick, 3/4 inch diamond mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation, with provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

2.04 COIL SECTION

A. Casing: Provide access to both sides of coils. Enclose coils with headers and return bends exposed outside casing. Slide coils into casing through removable end panel with blank off sheets and sealing collars at connection penetrations.

B. Drain Pans: 24 inch downstream of coil and down spouts for cooling coil banks more than one coil high.

C. Eliminators: Three break of galvanized steel, mounted over drain pan.

D. Air Coils:
   1. Certify capacities, pressure drops, and selection procedures in accordance with AHRI 410.

E. Fabrication:
   1. Tubes: 5/8 inch OD seamless copper expanded into fins, brazed joints.
   2. Fins: Aluminum.
   3. Casing: Die formed channel frame of galvanized steel.
2.05 FILTER AND AIR CLEANER SECTION
   A. General: Provide filter sections with filter racks, minimum of one access door for filter removal, and filter block-offs to prevent air bypass.
   B. Differential Pressure Gauge:
      1. Provide factory installed dial type differential pressure gauge, flush mounted with casing outer wall, and fully piped to both sides of each filter to indicate status.
      2. Maintain plus/minus 5 percent accuracy within operating limits of 20 degrees F to 120 degrees F.

2.06 DAMPER SECTION
   A. Mixing Section: Provide a functional section to support the damper assembly for modulating the volume of outdoor and return air.
   B. Damper Blades:
      1. Double-skin airfoil design with metal, compressible jamb seals and extruded-vinyl blade-edge seals on each blade.
      2. Self-lubricating stainless steel or synthetic sleeve bearings.
      3. Comply with ASHRAE Std 90.1 I-P for rated maximum leakage rate.
      4. Provide leakage testing and pressure ratings in compliance with AMCA 500-D test methods.
      5. Arrange in parallel or opposed-blade configuration.
   C. Barometric Relief Dampers:
      1. Frame: Roll formed galvanized steel.
      2. Blades: Roll formed galvanized steel.
      4. Material:

PART 3 EXECUTION

3.01 INSTALLATION
   A. Install in accordance with manufacturer's instructions.
   B. Bolt sections together with gaskets.
   C. Provide fixed sheaves required for final air balance.
   D. Make connections to coils with unions or flanges.
   E. Cooling Coils:
      1. Pipe drain and overflow to nearest floor drain.

3.02 SYSTEM STARTUP
   A. Provide manufacturer's field representative to perform systems startup.
3.03 CLOSEOUT ACTIVITIES

A. Demonstrate proper operation of equipment to Owner's designated representative.

END OF SECTION
SECTION 23 8110
TERMINAL HEAT TRANSFER UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES
A. Electric heaters.

1.02 RELATED REQUIREMENTS
A. Specifications throughout all divisions of the project manual are directly applicable to this section, and this section is directly applicable to them.

1.03 REFERENCE STANDARDS
A. The latest published edition of a reference shall be applicable to this project, unless identified by a specific edition date. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this project.

1.04 ACTION SUBMITTALS
A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
B. Product Data: For each type of product.
   1. Include rated capacities, operating characteristics, furnished specialties, and accessories for each unit type and configuration.
C. Samples: Color samples for initial selection for equipment with factory applied color finishes.

1.05 CLOSEOUT SUBMITTALS
A. Project Record Documents: Record actual locations of components and locations of access doors in radiation cabinets required for access or valving.
B. Operation and Maintenance Data: Include manufacturers descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listings.
C. Warranty: Submit manufacturer's warranty and ensure forms have been completed in Owner's name and registered with the manufacturer.

1.06 QUALITY ASSURANCE
A. Electrical Components: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

PART 2 PRODUCTS

2.01 ELECTRIC UNIT HEATERS
A. Manufacturers: Subject to compliance with requirements, provide basis of design products indicated on the drawings or comparable products by one of the following:
   1. Ouellet Canada, Inc: ouellet.com
3. TPI Corporation: tpicorp.com
4. Substitutions: See Section 20 0050 for substitution procedures.

B. Assembly: UL listed and labelled assembly with terminal box and cover, and built-in controls.

C. Heating Elements: Enclosed copper tube, aluminum finned element of coiled nickel-chrome resistance wire centered in tubes and embedded in refractory material.

D. Cabinet: 0.0478 inch steel with easily removed front panel with integral air outlet and inlet grilles.

E. Element Hangers: Quiet operating, ball bearing cradle type providing unrestricted longitudinal movement, on enclosure brackets.

F. Fan: Direct drive propeller type, statically and dynamically balanced, with fan guard.

G. Motor: Permanently lubricated, sleeve bearings for horizontal models, ball bearings for vertical models.

H. Control: Separate fan speed switch and thermostat heat selector switch, factory wired, with switches built-in behind cover. Provide thermal overload.

PART 3 EXECUTION

3.01 INSTALLATION

A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

B. Install in accordance with manufacturer's instructions.

C. Install equipment exposed to finished areas after walls and ceiling are finished and painted. Do not damage equipment or finishes.

D. Protection: Provide finished cabinet units with protective covers during balance of construction.

E. Electric Unit Heaters: Hang from building structure with hangers anchored to building. Mount as high as possible to maintain greatest headroom unless otherwise indicated.

F. Install electric heating equipment including devices furnished by manufacturer but not factory-mounted. Furnish copy of manufacturer's wiring diagram submittal. Install electrical wiring in accordance with manufacturer's submittals.

3.02 CLEANING

A. After construction is completed, including painting, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets.

B. Touch-up marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

3.03 SCHEDULES

A. See equipment schedules on the drawings for Basis of Design.

END OF SECTION
SECTION 25 5500
BUILDING AUTOMATION SYSTEM

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Instrumentation and control devices for replacement of an existing and upgrade to a new building automation system (BAS) comprised of direct digital controls.

B. Programming, functional testing, commissioning, training, and warranty service of the same.

1.02 RELATED REQUIREMENTS

A. Specifications throughout all divisions of the project manual are directly applicable to this section, and this section is directly applicable to them.

1.03 REFERENCE STANDARDS

A. Materials, equipment, installation, and workmanship shall comply with the most restrictive of local, state, and federal authority's codes and ordinances.

B. The latest edition of a reference shall be applicable to this project. All amendments adopted prior to the effective date of this Contract shall also be applicable.

C. American Society of Heating, Refrigeration, and Air Conditioning Engineers:

D. National Fire Protection Agency:

E. Underwriters Laboratories:
   1. UL 916 - Standard for Energy Management Equipment.

1.04 DESCRIPTION OF THE WORK

A. The following is a summary of the scope of work for this project, with descriptive details of unique aspects of the project. See the remainder of this specification for other more detailed requirements.

B. Provide all labor, materials, equipment, and services necessary and incidental for a complete Building Automation System (BAS) comprised of various types of BACnet BTL-listed products (B-BC and B-AAC Direct Digital Control (DDC) Controllers, B-RTR BACnet Routers, B-AWS Operator Interface), electronic actuation, conventional electric/electronic controls, and equipment-mounted controls. Include all software and hardware for all specified capabilities. No B-ASC, B-SA, or B-SS Controllers are permitted.
C. Provide pre-construction and as-built submittal documentation that shows all BAS equipment. Submit graphic screen shots for Owner's prior review. Provide testing for system acceptance, owner operator training, and warranty services as described.

D. Incorporate hardware resources sufficient to meet the functional requirements of these specifications. Include all items, not specifically itemized herein, that are necessary to implement, maintain, and operate the system in compliance with the functional intent.

E. All controls required by this project shall be integrated into a single controls system and coordinated by the contractor as follows. Contractor is defined herein as responsible for this project in its entirety.
   1. The contractor is responsible for providing all controls described in the construction documents regardless of where within the documents these controls are described.
   2. The contractor is responsible for all points, devices, field wiring, power requirements, programming, graphics, and commissioning to satisfy the intended sequences.
   3. The contractor shall coordinate the resolution of any incompatibility issues between the control products provided under this section and those that may be provided elsewhere in this specification.
   4. The contractor is responsible for all material and labor to install and interconnect control products provided by other suppliers regardless of where these products are described within the construction documents.

F. Provide all hardware licensing fees, annual software maintenance, security patches, firmware upgrades, etc, including installation labor, for an additional 5-years from the date of substantial completion, at no additional cost to the Owner. State as such in a warranty letter.

1.05 RELATED WORK

A. Items supplied under this section are specified for installation under other mechanical specification sections may include but are not limited to: dampers, valves, flow switches, flow sensors, thermal wells, and pressure taps, etc. This contractor will be responsible for proper installation and operation of the devices.

B. Items specified under other mechanical sections that are part of, integrated with, or installed under this section may include but are not limited to: plant controls, terminal unit accessories (crossflow sensor, fan relay, transformer), and variable speed drives, etc. See the associated specification sections for more information.

C. Power: All power for the BAS shall be independently circuited (not on with any other building or equipment circuits). See the electrical drawings for locations of 120V power available. Any additional power required, or power required in different locations, shall be provided under this section, and installed in compliance with requirements of the electrical specifications.

D. Ethernet/IP: The contractor shall utilize the building's communications infrastructure for Ethernet/IP communications. See the electrical drawings for locations of Owner provided switches for BAS local and internet communications.
   1. The contractor shall be responsible for wiring between the BAS and the switch ports provided by the Owner for the BAS. Wiring shall be in accordance with the electrical specifications.
   2. Prior to submittals, the contractor shall meet with the owner’s IT staff to discuss the BAS Ethernet/IP communications requirements, to confirm locations of switches to be used by the BAS, and to provide the owner any information needed for setting up secure communications (e.g., VLAN, VPN, VRF, etc).
3. The Operator Interface hardware (i.e., the "Web Server" PC) shall be located in and connected to the Owner’s network in the building’s admin server room. The hardware shall be installed in a UPS-backed server rack provided by the Owner.

4. The BAS Ethernet/IP wiring design shall be shown in the submittals and subject to owner review.

E. Wiring Requirements: Install wiring, boxes, and raceway in accordance with NEMA standards. Provide all components, fittings, supports, and accessories for a complete raceway system. All wiring shall be routed in appropriate raceway, approved for the application. Power wiring shall be separated from communications wiring.

F. Fire Alarm System: Duct smoke detectors and/or fire alarm fan shutdown modules, and other fire alarm-controls (fire/smoke dampers), are by the electrical contractor. The contractor shall ensure all life safety interlocks to motor starters or variable frequency controllers are installed.

G. Test and Balance: Provide assistance to the efforts specified in the testing and balancing specification. This assistance shall include on-site instruction on operator interface to the BAS, the provision of software and any special hardware to allow operator interface, and instruction on access to all setpoints or parameters that need to be adjusted for balancing.

H. Thermostats: Install/wire all thermostats provided with equipment specified in other mechanical specification sections at the locations shown.

1.06 ACTION SUBMITTALS

A. Product Data: For each type of product include the following:
1. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
4. Installation, operation and maintenance instructions including factors effecting performance.
5. Each submitted piece of product literature shall clearly cross-reference specification and drawings that submittal is to cover.
6. When manufacturers cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be clearly indicated.
7. Data sheets for DDC Controllers and BACnet Routers shall include the BTL mark and the listing’s BACnet Device Profile.
8. All data sheets shall be keyed to the shop drawing bill of materials lists.

B. Control Valve Schedule: Submit a control valve schedule indicating service, size, arrangement, flows, flow coefficient, pressure drop, normal position, close-off rating, and pressure rating for each system.
1. Include model number, dimensions, and maintenance clearance for installation.
2. Include actuator selection supported by calculations required to move, close, and seal the valve at design conditions.

C. Damper Schedule: Submit a damper schedule indicating service, size, flows, pressure drop, normal position, leakage class, and blade configuration for each system.
1. Include model number, orientation and axis of frame, and blade rotation for installation.
2. Include actuator selection criteria and the maximum leakage rate at the operating static pressure differential.

D. AMD Schedule: Provide a schedule for airflow measurement devices (AMD) indicating the make, model, and type of device, the number of sensors per location, duct area, sensor density, and placement requirements.

E. Graphics Screens: Submit custom-developed sample graphics for the controls included in this project. Submit screen captures to the Engineer for Owner review and comment prior to implementation.
   1. The screens shall include schematic representations of all controlled and/or monitored systems/equipment, points and relevant setpoints/parameters, and dynamic thermo- graphic floor plans with all space sensing points represented.
   2. See the execution section of this section for additional information and requirements.

F. Exceptions List (Pre-Bid):  
   1. With prior approval, the contractor may use alternate products, means, methods, or strategies that meet the functional intent of these specifications.
   2. Submit an exception list of all items for which the contractor cannot explicitly conform to a requirement of these drawings and/or specifications.
   3. The list shall include the article, paragraph, and sub-paragraph number, the requirement to which exception is taken, and a description for meeting the functional intent.
   4. The list shall be submitted at least 10 calendar days prior to the bid, and only those accepted by addendum will be permitted.
   5. The contractor shall meet all requirements as specified that are not indicated on the approved exception list.

1.07 INFORMATIONAL SUBMITTALS

A. Qualifications: Submit documentation that the system provider, programming specialist, and field installers meet the quality assurance requirements of this section.

B. Testing: Submit documentation that will be used to validate point-to-point tests and functional performance testing prior to requesting acceptance by the Owner or Engineer. Provide a description of all system acceptance tests along with the contractor's forms, checklists, procedures, and trends used in the testing.

C. Training: Submit course outline and materials for each class at least six weeks before first class. Training shall be furnished via instructor-led sessions, computer-based training, or web-based training. The Owner or Engineer will modify course outlines and materials if necessary to meet the Owner's needs.

1.08 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Manuals: At a minimum, include the following:
   1. Written contractor's warranty.
   2. End user licensing agreements.
   3. Copy of software licensing file.
   5. As-built versions of product data.
   6. List of recommended spare parts lists.
   7. Operating and maintenance cautions and instructions.
   8. An operator's manual, which will include detailed instructions for all operations of the building automation system.
9. A programmer's manual, which will include all information necessary to perform programming functions.
10. All original issue documentation, software, and licensing for Third-Party hardware and software (where applicable).

B. Software Editors: Submit all software service tools used for operator interface, programming environment, networking, database management, etc used by the contractor to install the system, or needed to operate the system to its full capabilities.
   1. All software shall be available and functional on the web server, operator workstations, and/or portable operator terminals where provided.
   2. Software shall be the latest release available as of the date of substantial completion, licensed to the owner.
   3. Provide digital backups for all software provided so that the owner may reinstall any software as needed.
   4. Include all proprietary cables necessary for connecting to controllers.

C. Testing Documentation: Submit completed control system test forms, checklists, point-to-point logs, and functional performance testing documentation. Include screenshots and trend logs to validate that all programming is in accordance with the specifications.

D. Training Validation: Submit attendance logs, including dates and times, for each knowledge level and all training sessions held. Include written descriptions summarizing topics covered in each session.

E. Updates: Submit written validation (in the form of a letter) that all software, firmware, drivers, etc have been updated to the latest version release as of the date of substantial completion.

F. Licensing: Submit written validation (in the form of a letter) that all licensing and software maintenance fees, including installation labor, is being provided for the period listed herein.

G. Provide all of the above in both hard-copy and portable digital file formats (where applicable).

H. Where applicable, provide workstations, laptops, or tablets, fully configured, ready for use.

1.09 QUALITY ASSURANCE

A. General:
   1. System shall be by a nationally recognized manufacturer of direct digital control systems and products, having published catalog literature, installation, operation, and maintenance manuals for all products intended for use.
   2. Materials and equipment shall be the manufacturer's latest standard design that complies with specification requirements. All materials and equipment shall be new unless otherwise specified.
   3. All electrical work shall comply with the latest version of the National Electrical Code, and electrical divisions of this specification.
   4. Provide electrical products that have been tested, listed and labeled by UL and comply with NEMA standards.

B. System Provider Qualifications:
   1. Authorized and trained representative of the proposed system manufacturer.
   2. Demonstrated experience with installations of similar complexity prior to the time of bid.
   3. Demonstrated past experience on at least five projects of similar point-count, complexity, scope, and value.
   4. Having service and maintenance staff stationed within 60-miles and assigned to support the project during the warranty period.
5. Having product parts inventory to support on-going system operation after the date of substantial completion.

C. Installer Qualifications:
   1. Demonstrated experience with the installation of the proposed product line for not less than two projects of similar size and complexity. Submit names of proposed individuals and documented experience.
   2. Individuals overseeing the installation and configuration of the proposed product line must provide evidence of the most advanced training offered by the manufacturer on that product line for installation and configuration.

D. Programmer Qualifications:
   1. Demonstrated experience with programming of the proposed product line for not less than five years and not less than five projects of similar size and complexity.
   2. Individuals involved with programming the site-specific sequences shall provide evidence of the most advanced programming training offered by the vendor of the programming application offered by the manufacturer.

1.10 WARRANTY

A. Manufacturer and installer agree to repair or replace products that fail in materials or workmanship for a period of one year after the date of final acceptance.
   1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.

B. Maintenance Service:
   1. Maintenance service shall be provided thru-out the warranty period for all software, firmware, and hardware specified in the project, at no additional cost. Service all equipment per the manufacturer's recommendations.
   2. Preventative maintenance shall be provided thru-out the warranty period in accordance with the hardware component manufacturer's requirements.

C. Normal Service:
   1. Any malfunction, failure, or defect in hardware component, or failure of any control programming that would not result in property damage or loss of comfort control shall be corrected and repaired following notification by the Owner as follows:
      a. Response by telephone to any request for service shall be provided within 8-hours during a normal 40-hour work week.
      b. In the event the issue cannot be resolved remotely, at least one trained technician shall be dispatched to the project site within three (3) working days.

D. Emergency Service:
   1. Any malfunction, failure, or defect in hardware component, or failure of any control programming that would result in property damage or loss of comfort control shall be corrected and repaired following notification by the Owner as follows:
      a. Response by telephone to any request for service shall be provided within 2-hours of the Owner's initial telephone request.
      b. In the event the issue cannot be resolved remotely, at least one trained technician shall be dispatched to the project site within 4-hours of the initial request.
      c. Emergency service during the warranty period shall be provided 24-hours per day, 7-days per week, with no exceptions and at no additional cost to the Owner.

E. Software:
1. Updates, security patches, or version upgrades to software and firmware shall be installed when available and as necessary to resolve discrepancies.
   a. All system software, firmware, drivers, etc will be upgraded to the latest version release as of the date of substantial completion.
   b. Provide any additional software upgrades after the date of final acceptance, including installation, at no additional cost to the Owner.
   c. Install updates only after receiving Owner's written authorization.

F. Notice Given:
   1. The contractor shall notify the Owner any time the contractor is on-site for service.
      a. Notify Owner's personnel of all anticipated service work. No work affecting system operation shall commence unless express permission is granted.
      b. After completed, a work order ticket describing in detail all the work performed, hours worked, and follow-up required, shall be forwarded to the owner's personnel.

G. Written Warranty:
   1. The contractor shall submit with the Operation and Maintenance manual a written warranty addressed to the Owner, acknowledging all requirements stated herein, including annual software maintenance upgrades and licensing renewals (where applicable).
   2. The contractor shall submit with the Operation and Maintenance manual a written end user software maintenance and license agreement filled out in the Owner's name.

PART 2 PRODUCTS

2.01 MANUFACTURERS AND PROVIDERS

A. Subject to requirements specified herein, pre-qualified manufacturers and system providers are as follows:
   1. Tridium N4 and Distech Controls provided by Long Building Technology (LBT) of Casper, WY.
   2. Johnson Controls Metasys provided by Johnson Controls (JCI) of Casper, WY.
   3. Substitutions: See Section 20 0050 for substitution procedures.

B. BACnet Conformance: Unless noted otherwise, all of the products used shall be shown to meet BTL conformance requirements as part of the submittal process or the contractor shall select one of the other listed manufacturers in order to meet the requirements.

C. All DDC controls shall be by one manufacturer, except when controls are specified under another section (i.e., referenced as "controls provided with equipment," "factory-mounted controls," "manufacturer provided controls," etc within this section). The term "DDC controls" includes DDC Controllers, BACnet Routers, and Operator Interface software. Field devices and EIA-485-to-IP or EIA-to-ARCNET routers need not be by the same manufacturer.

D. Open Licensing: The Owner shall be the named license holder of all DDC Device and Operator Interface software/firmware provided on this project. The intent of this requirement is to provide an open system such that products from various suppliers can be integrated into this BAS; and to allow the Owner or any contractor of their choosing to have full access to the system for expansion, maintenance, and service.

E. Substitutions: Any installing contractor, not listed as pre-qualified, shall submit credentials as detailed below for review by the Owner and the Design Team. Credentials must attest that the contractor meets all requirements of the specification. The design team’s judgement regarding approval to bid as an acceptable installer after reviewing the data will be final.
1. All information must be submitted at least three weeks prior to the published bid date to allow the design team adequate time to review the bidder’s credentials. The pre-bid submittal shall contain the following information at a minimum:
   a. A profile of the manufacturer and the local installation and service organization.
   b. System architecture with single line riser diagram showing all major components (controllers, routers, hubs, etc) that will be required for the project.
   c. Product data sheets for all components, DDC Controllers, and all accessories listed per the appropriate specification sections herein.
   d. Examples of actual graphic screens from other similar projects, including floor plan graphics, equipment graphics, and any other graphics pertinent to the project.
   e. A copy of this specification in its entirety with initials beside each article to signify that the manufacturer’s equipment and software fully conforms to the specified requirements. If the requirement cannot be met, indicate on a separate exceptions list, the reasons or limitations, and the alternative proposed.
   f. A list of three similar systems in size, point capacity, and total installed value, installed and commissioned by the local office with a list of the installers, and the owner’s contact information.
   g. Resumes for all employees who will be involved with the project design, installation, commissioning, and post install service. Resumes shall include copies of manufacturer’s certifications for the proposed product line.
   h. An interview may be conducted and the bidder will be requested to make a formal presentation concerning the proposed system and possibly provide an installed project tour prior to the final decision.

2. The approved installer’s local field office shall have a minimum of 5-yrs of installation experience with the manufacturer and shall provide documentation in the submittal package verifying longevity of the installing company’s relationship with the manufacturer.
   a. The contractor shall have an in-place support facility within 60-miles of the project site with factory certified engineers, spare parts inventory, and all necessary test and diagnostic equipment for the installed system.
   b. The contractor shall have 24-hr/7-day/week emergency service available.
   c. The contractor shall meet all quality assurance requirements stated herein.

2.02 OPERATOR INTERFACE

A. General Requirements: The Operator Interface web server shall reside on a high-speed network with System Controllers. The system shall support Thin Client access, with an unlimited number of simultaneous clients using a standard internet web browser to perform all of the capabilities described herein. Operator Workstation software shall be BTL-listed, conforming to the BACnet Advanced Workstation (B-AWS) device profile (as specified in ASHRAE 135, BACnet Annex L). Allowable products, along with any additional/optional software modules needed to provide the software features required herein, are:
   1. LBT: N4 Supervisor with Workbench/Workplace Tech.
   2. JCI: ADX with GGT, SCT and CCT.

B. System Software:
   1. System Graphics: The system shall provide display of custom graphic screens with dynamic point information and the ability to show animation by shifting image properties based on the status of the point. The terms “graphic screens” and “graphics” in this specification refer to graphical images viewed via a web browser (Thin Client).
   2. Graphics Generation: Custom graphic files shall be created with the use of a graphics generation package furnished with the system. The package shall be a graphically based system to create and modify graphics that are saved in industry standard formats. The
package shall also provide the capability of capturing or converting graphics from other programs.

3. Vector Graphics: All graphic screens shall be configured with scalable vector graphics technology, using a responsive design that automatically adjusts resolution to the browser using it, viewable without the need for horizontal scrolling, and tested at several current popular device/screen resolutions. Graphics shall be optimized for mobile support and responsive to the device type.

4. Graphics Library: Furnish a complete library of standard system graphics, such as boilers, chillers, air handlers, terminal units, fan coils, and unit ventilators. The library shall also include standard component symbols for other equipment, including fans, pumps, coils, valves, piping, dampers, ductwork, etc. The library shall be in a file format compatible with the graphics generation package.

C. System Applications:
1. Automatic System Database Save and Restore: Each workstation or web server shall store on the hard drive a copy of the current database of each DDC Controller. The database shall be automatically updated whenever a change is made in any DDC Controller.

2. Manual System Database Save and Restore: A system operator with proper password clearance shall be able to save the database from any DDC Controller. The operator shall also be able to clear a DDC Controller's database and manually initiate a download of a specified database to any panel in the system.

3. System Configuration: Provide an application for BAS configuration of the system (DDC Controller communications addressing, point definition, etc), allowing for future system changes or additions by users under proper password protection.

4. Online Help: Provide a context-sensitive, online help system to assist in operation of the BAS. Online help shall be available for all applications and shall provide the relevant data for that particular screen.

5. System Diagnostics: The system shall automatically monitor the operation of all DDC Devices including network communications and provide an alarm when a failure occurs.

D. Security Features:
1. Each operator shall be required to log on to the system with a user name and password in order to view, edit, add, or delete data.

2. Operator Access. The user name and password combination shall define accessible viewing, editing, adding, and deleting privileges for that operator.
   a. Users with system administrator rights shall be able to create new users and edit the privileges of all existing users.
   b. System Administrators shall also be able to vary and deny each operator's privileges based on the geographic location.
   c. Example: the ability to edit operating parameters in Bldg A, to view but not edit parameters in Bldg B, and to not view or edit in Bldg C.

3. Password Policy Rules: System administrator shall invoke policies for minimum password strength, including number of characters, special characters and numbers, upper and lower case, etc.

4. Automatic Log Out: Automatically log out each operator if no keyboard or mouse activity is detected. This auto logoff time shall be user adjustable.

5. Encrypted Security Data: Store system security data including operator passwords in an encrypted format. System shall not display operator passwords.

6. Audit and Security Detail: All users accessing the system shall have their actions recorded. Information recorded shall include: login/logout time and date; system modifications (with before and after values); ability to report user activity based on individual and/or date and time.

E. Standard Operating Features:
1. **Point/Data Overrides/Modifications**: Output points and system data (i.e., setpoints) shall be modifiable (i.e., auto vs. manual and overridden value) via a link to each item's graphic screen image.

2. **Alarm Processing**: An alarm log with acknowledgement and alarm clearing functions; and the ability to configure alarm limits, priority levels, and system reactions (e.g., email, text message, dial-out, etc.). Alarms shall use BACnet Alarm and Event Services.

3. **Scheduling**: A graphical method for scheduling equipment operation including normal, weekend, holiday, and exception scheduling. Scheduling shall use BACnet Calendar and Schedule Objects.

4. **Trend Logs**: The ability to define and view custom historical trend logs for any data object in the system, both stored and archived. The data may be displayed in tabular or graphical formats. Trends shall use BACnet Trend Objects.

5. **Trend Graphs**: Software shall be capable of creating two-axis graphs relative to time that display a minimum of twelve concurrent object types using unique colors.
   a. Any system point may be trended at time-based intervals or change-of-value, both user definable.
   b. Operators shall be able to create custom trend graphs for all physical points, virtual points, and/or calculated variables.
   c. Operators shall be able to edit graph configuration to display a specific time period or data range.
   d. Setup and viewing may be accessed directly from any graphics on which the object is displayed.

**F. Control Software Editors:**
1. **Controllers**: A full screen graphical editor for each type of application that allows the operator to view and change the configuration, parameters, and setpoints for all controllers.
2. **Custom Programming**: A graphical editor for creating, modifying, and debugging the custom control programming and database management functions for all DDC Controllers.
3. **Install the software on the Web Server for use via a Thin Client PC or provide the software with licensing for use on up to two portable operators terminals.**
4. **Custom programming language shall include if/then/else logic, Boolean logic (e.g., OR, AND, etc) operators, math operators (e.g., +, -, / , powers, roots, etc), math comparison operators (e.g., =, >, <, =>, etc), count down/up timers, access to time clock and scheduling information, access to input point values, the ability to modify output point values/states, access to alarm information (including those built-in for controller health and/or communications monitoring), access to trend log information, access to data in other controllers, built-in HVAC control functions (e.g., PID, optimum start, thermostatic on/off control, psychrometric calculations, deadband, high/low selector, etc), etc.**

**G. Other Requirements:**
1. **Third-Party Software**: Provide any other software needed for the operation of the Operator Interface software, such as Microsoft SQL or .NET, Visio, Excel, etc.
2. **Java Web Applets**: Systems that use Java web applets are not permitted. Only native browser-based user interfaces (HTML5 only) that do not require Thin Client plug-ins are acceptable.

**H. Software Maintenance**: All Operator Interface software and programming tools shall be updated to the most current version and all licenses shall be renewed to the level specified herein at the completion of the project.

**I. Operator Interface Hardware:**
1. **Portable Operator's Terminal**: Provide one new Microsoft Windows-based notebook PC. Configure for interface with any DDC Device in the system, and furnish all required communication ports and cables for proper operation. Minimum specifications:
a. Windows 10 Pro x64 with MS Edge web-browser.
b. 3.0 GHz Core i7 processor, 8GB RAM.
c. 512 GB hard disk drive, HD graphics.
d. 13-inch color screen, integral pointing device.

2.03 AIRFLOW MEASURING DEVICE

A. Electronic low flow airflow measurement devices (AMD) shall be UL listed thermal dispersion type with one self-heated bead-in-glass thermistor and one zero power bead-in-glass at each sensing node. Basis of design is model EF-x1000-T as manufactured by Ebtron, Inc.

B. Sensor Probe: Extruded aluminum alloy tube, stainless steel mounting brackets, solder joined internal wiring connections, with two bead-in-glass, hermetically sealed thermistors potted in a marine grade waterproof epoxy.

C. Transmitter: Integral microprocessor-based, electroless nickel immersion gold plated circuit board and interconnects, powered by 24 VAC, capable of identifying malfunction, with field selectable analog outputs for airflow (and temperature) or digital non-isolated RS-485 network connection for BACnet MS/TP or Modbus.

PART 3 EXECUTION

3.01 GENERAL INSTALLATION

A. Install components in accordance with manufacturer's instructions. Where the drawings conflict with these instructions, the contractor shall submit a written request for clarification.

B. Electrical products and execution shall comply with requirements of the National Electric Code, the authority having jurisdiction, and applicable electrical sections of these specifications.

C. The contractor shall review the scope of work of other trades and coordinate installation to avoid field conflicts.

END OF SECTION
SECTION 26 0010
GENERAL ELECTRICAL REQUIREMENTS

PART I - GENERAL

1.01 RELATED DOCUMENTS AND REQUIREMENTS

A. Specifications throughout all divisions of the project manual are directly applicable to this section, and this section is directly applicable to them.

B. Drawings, specification sections and other documents which form the basis for the Contract apply to all work of Division 26.

1.02 SUMMARY

A. This section includes general requirements for electrical work and is supplemental and in addition to the requirements of Division 01. Section applies to work of all Division 26 sections.

B. It is the intent of Division 26 and the contract drawings to describe and provide for the furnishing, installing, testing and placing in satisfactory and fully operational condition all equipment, materials, devices and necessary appurtenances to provide a complete electrical system.

C. Provide all materials, appliances, apparatus, safety precautions, programs and methods, whether specifically mentioned or not, which are necessary for a complete electrical installation.

1.03 REGULATORY REQUIREMENTS

A. Errors and omissions in the Contract Documents do not relieve the contractor from providing the work in accordance with regulatory requirements.

B. As a minimum, execute, test and inspect work in accordance with Underwriters and State and Local codes, rules, and regulations applicable to the trade involved. If plans or specifications call for requirements in excess of these codes, rules and regulations, the greater requirement shall apply. Included are the requirements of IBC, NFPA, NEC, OSHA, NEMA, ICEA, ANSI, ASTM, UL, EIA/TIA, UBC, and Federal Specifications.

C. Obtain and pay for all permits, licenses, and inspections required by laws, ordinances and rules that govern the work of this project.

D. Where a conflict between Division 26 drawings and specifications arise, The specifications shall take precedence.

E. All materials furnished and all work installed shall comply with locally adopted, international, or uniform building and fire protection codes, with the requirements of local utility companies, and with the requirements of all governmental authorities having jurisdiction.

1.04 DRAWINGS

A. The drawings are to scale as noted; however refer to the architectural plans for exact building dimensions and civil plans for exact site dimensions. Do not scale electrical drawings.

B. Drawings are diagrammatic. No attempt has been made to show every conduit, fitting, device, connection or detail of construction.

C. Consult other drawings of the project for correlating information. Pay particular attention to door swings, casework, fixed furniture, piping, radiation and structural steel. No additional compensation will be allowed for the moving of misplaced items.

D. Since drawings are at a small scale, outlets, devices, equipment, etc., are indicated only in their approximate locations. Verify final locations for rough-ins with field measurements and with the
requirements of the equipment to be installed. In the event of conflicts with other systems or building components, notify the Architect whose decision will govern. Make changes required to correct conflicts at no change in contract cost to the Owner.

E. Coordinate space requirements, supports, and installation of mechanical and electrical work which are indicated diagrammatically on Drawings. Follow routing shown for pipes, ducts, and conduit, as closely as practicable; place runs parallel with lines of building. Utilize spaces efficiently to maximize accessibility for other installations, for maintenance, and for repairs.

1.05 PROJECT COORDINATION

A. Make the following types of submittals to Architect through the Project Coordinator:

1. Preconstruction Submittals
   a. Requests for Substitution.
   b. Proposed Product Lists.
   c. Shop drawings, product data, and samples.
   d. Coordination Drawings.
   e. Manufacturer’s Instructions.

2. Construction Submittals
   a. Requests for Interpretation.
   b. Proposal Requests
   c. Credit/Deduct Change Orders

3. Substantial Completion Submittals
   a. Source Quality Control Test Reports
   b. Field Quality Control Test and Inspection Reports.
   c. Schedule of Owner Training.

4. Closeout Submittals
   a. Corrected Test and Inspection Reports.
   b. Certification of Owner Training.
   c. Maintenance Materials.
   d. Operation & Maintenance Manuals.
   e. Inspector Certificates of Acceptance
   f. Warranty Certificates

B. Coordinate work with other Contractors and trades doing work on the project. Examine drawings and specifications of other trades for construction details. Make every effort to prevent conflicts or interferences with other trades.

C. Before ordering equipment, determine that equipment will pass through building openings and passageways that provide unobstructed access to final equipment locations. Determine that equipment will properly fit in the designated space without conflict with other systems, and that Code required spaces and access can be maintained.

D. Coordinate scheduling, submittals, and work of the various sections of the Project Manual to ensure efficient and orderly sequence of installation of interdependent construction elements, with provisions for accommodating items installed later.

E. Verify that utility requirements and characteristics of new operating equipment are compatible with building utilities. Coordinate work of various sections having interdependent responsibilities for installing, connecting to, and placing in service, such equipment.

F. Comply with working clearances identified in Article 110-26 2017 NEC and coordinate with Division 22 and Division 23 subcontractor to insure that no piping, ductwork or equipment is
installed in the exclusively dedicated space for switchboards or panelboards within the scope of the NEC.

G. After Owner occupancy of premises, coordinate access to site for correction of defective work and work not in accordance with Contract Documents, to minimize disruption of Owner's activities.

1.06 JOB CONDITIONS

A. Examine the project site prior to bidding and become familiar with all existing conditions that may affect the bid, No subsequent allowance for time or money will be considered for any consequence related to failure to examine site conditions.

B. Inspect materials upon arrival at the site and verify conformance with Contract Documents. Containers that are broken, opened, damaged or water marked are unacceptable. All material, except items specifically designed to be installed outdoors, shall be stored in an enclosed dry building or trailer.

C. Protect work, materials and equipment from theft and damage. Be responsible for any such theft or damage until project acceptance by the Owner.

PART 2 - PRODUCT REQUIREMENTS

2.01 STANDARDS

A. Unless otherwise indicated, provide only first-quality new materials and equipment, free from defects, in first class condition, suitable for the application and for installation in the space provided. Unless specifically required or permitted by the Contract Documents.

B. Unless otherwise indicated, material and equipment shall be the standard current products of manufacturers regularly engaged in the manufacture of such products.

C. Provide material and equipment listed by UL or other approved testing organization wherever standards have been established for that product unless otherwise permitted by the Authority Having Jurisdiction. Custom designed products shall be constructed from UL approved materials and approved by UL as a complete assembly.

D. Where two or more products of the same class are required, provide products of a single manufacturer.

2.02 SUBSTITUTIONS

A. Products are specified by naming one or more manufacturers with a provision for substitutions. Submit any requests for substitution of specified materials not named prior to bidding in accordance with the provisions of Division 01.

B. Provide sufficient material or data to allow evaluation of proposed alternatives and determination of compliance with the Contract Documents. Specifically List any deviations from the Contract Documents.

C. Where such alternatives alter the design or space requirements, include in the proposal, all items of cost for revised design and construction, including the cost of all allied trades involved.

D. Where specific products are mentioned by name or part number, the proposed substitute must meet all the standard services and functionality of the specified system weather explicitly mentioned or not.

E. Division 01 instructions to Bidders specify time restrictions for submitting requests for substitutions during the bidding period. Comply with requirements specified in this section.
F. All product substitutions shall be by addendum, or with written approval only.

G. Substitutions after the bid will be considered when a product becomes unavailable through no fault of the EC.

H. Document each request with complete data substantiating compliance of proposed substitution with Contract Documents.

I. A request for substitution constitutes a representation that the submitter:
   1. Has investigated proposed product and determined that it meets or exceeds the quality level of the specified product.
   2. Will provide the same warranty for the substitution as for the specified product.
   3. Will coordinate installation and make changes to other Work which may be required for the Work to be complete with no additional cost to Owner.
   4. Waives claims for additional costs or time extension which may subsequently become apparent.

J. Substitution Submittal Procedure:
   1. Submit three copies of request for substitution for consideration. Limit each request to one proposed substitution.
   2. Submit shop drawings, product data, and certified test results attesting to the proposed product equivalence. Burden of proof is on proposer.

2.03 SUBMITTALS

A. Proposed Products List: Submit list of major products proposed for use, with name of manufacturer, trade name, and model number of each product.
   1. Product Data Submittals: Submit manufacturer's standard published data. Mark each copy to identify applicable products, models, options, and other data. Supplement manufacturers' standard data to provide information specific to this Project.
   2. Shop Drawing Submittals: Prepared specifically for this Project.
   3. Submit shop drawings and product data as required by various sections of Division 26, in accordance with Division 01. Make submittals to the Architect via the Project Coordinator.
      a. Do not submit directly to the Engineer
   4. Do not use materials and equipment removed from the existing premises, except as specifically permitted by the Contract Documents.

B. Provide submittals for equipment as described in the electrical drawings as well as each section of these electrical specifications, including, but not limited to all sections of Division 26.

C. Submittals will be reviewed by the Engineer only for general compliance with the intent of the Contract Documents. Review does not extend to details of construction, dimensions or equipment quantities.

D. Review of submittals and action recommended as a result of review is a courtesy extended to the Contractor by the Engineer. Errors in submittals are the sole liability of the Contractor. Submission of material for review does not alter the Contractors responsibility to comply with the Contract Documents regardless of action noted in the Engineer's review.

E. Submittals shall include all information necessary to properly identify and evaluate all components of the equipment being submitted for review. Any proposed equipment variances from the Contract Documents must be clearly highlighted. If this is not done the Engineer reserves the right to reject such equipment at any time before or after installation.

F. Submittals shall be bound in folders with covers that indicate the project name and equipment included within the folder. The Contractor's review stamp, dated and initialed, shall be on the
folder cover or cover page. Provide tab dividers, properly identified, to identify different categories of equipment. If more than one item of equipment is shown on the same catalog page, that equipment which is applicable to the project must be clearly identified.

1. Contractor’s stamp implies that review, approval, verification of products required, field dimensions, adjacent construction work, and coordination of information is in accordance with the requirements of the Work and Contract Documents.

G. Incomplete or improperly formatted submittals will not be reviewed.

H. When revised for resubmission, identify all changes made since previous submittal.

**PART 3 - ADMINISTRATIVE REQUIREMENTS**

3.01 **NOT USED - REFER TO 01 FOR REQUIREMENTS**

**PART 4 - EXECUTION REQUIREMENTS**

4.01 **GENERAL**

A. Workmanship shall be first quality and none but competent electricians, licensed in the State of Wyoming, shall be employed. All work shall be performed under supervision of an experienced, and competent foreman, licensed in the State of Wyoming, and in complete compliance with all applicable codes.

B. The finished appearance of electrical work shall be first class. Install systems, materials and equipment level and plumb, and parallel and perpendicular to building components where installed exposed. Install electrical equipment to facilitate servicing, maintenance and repair or replacement of equipment components.

C. Follow manufacturer’s installation instructions explicitly unless otherwise indicated. Whenever any conflict arises between the manufacturer’s instructions and the Contract Documents notify the Architect and comply with Architect’s decision. Keep copy of manufacturer’s installation instructions on job site available for review at all times.

D. Do no work without proper documents or written instruction. Any work completed without proper authorization will not be considered for additional compensation.

E. Contractor shall replace any improperly executed work at his cost.

F. Install electrical equipment to facilitate servicing maintenance and repair of replacement of equipment components. Connect equipment for ease of disconnecting, with minimum of interference with other installations.

G. In finished areas, except as otherwise indicated; conduit and wiring within the construction. Coordinate locations of fixtures and outlets with finish elements.

H. No back to back electrical boxes inside walls, maintain a 6” inch minimum spacing between boxes and no more than 2 boxes in any joist space.

I. All ceiling mounted devices (i.e. smoke detectors, speakers, light fixtures, etc.) shall be installed centered in ceiling tiles. Coordinate with ceiling installer.

J. Electrical devices are shown on Drawings in approximate locations unless dimensioned. Adjust devices up to five feet if required to accommodate intended purpose.

K. Verify that existing site conditions and substrate surfaces are acceptable for subsequent work. Start of work means acceptance of existing conditions.

L. Examine and verify specific conditions described in individual specification sections.
M. Verify that utility services are available, of the correct characteristics, and in the correct locations.

4.02 TRANSPORTATION, STORAGE, AND PROTECTION

A. Transport and handle products in accordance with manufacturer's instruction. All transportation costs for Division 26 equipment shall be by this contractor.

B. Store and protect products in accordance with manufacturer's instructions.

C. Store with seals and labels intact and legible.

D. Store sensitive products in weather-tight, climate controlled, enclosures in an environment favorable to product.

E. For exterior storage of fabricated products, place on sloped supports above ground.

F. Provide off-site storage and protection when site does not permit on-site storage or protection. Certificate of insurance is required for off-site storage.

G. Arrange storage of products to permit access for inspection. Periodically inspect to verify products are undamaged and are maintained in acceptable condition.

H. Protect installed work and provide special protection where specified in individual specification sections.

4.03 TEMPORARY LIGHTING AND POWER

A. Temporary Power
   1. Provide adequate distribution equipment, wiring, and outlets to provide single phase branch circuits for power and lighting.

B. Temporary Lighting
   1. Provide and maintain incandescent lighting for construction operations per OSHA 1926.56.
   2. Provide branch wiring from power source to distribution boxes with lighting conductors, pigtails, and lamps as required.
   3. Maintain lighting and provide routine repairs. Replace lamps as required during construction phase. Task lighting for painting and finishing shall be provide by the associated contractor.
   4. Upon completion of the work, remove all temporary facilities from the project site.

C. Promptly notify the architect of any discrepancies discovered.

4.04 CUTTING AND PATCHING

A. Obtain permission from the Architect and coordinate with other trades prior to cutting. Conform to Architect's direction for location and method of cutting. Cut carefully, and only the minimum amount necessary.

B. Submit written request in advance of cutting or alteration which affects:
   1. Structural integrity of any element of Project.
   2. Integrity of weather exposed or moisture resistant element.
   3. Efficiency, maintenance, or safety of any operational element.
   5. Work of Owner or separate Contractor.
   6. Include in request:
      a. Location and description of affected work.
      b. Necessity for cutting or alteration.
c. Description of proposed work and products to be used.

C. Repair any damage equal to the original condition, at minimum. Use materials and methods acceptable to the Architect.

D. Cut rigid materials using masonry saw or core drill. Pneumatic tools not allowed without prior approval.

E. Fit work air tight to conduit and other penetrations through surfaces.

F. At penetrations of fire rated walls, partitions, ceiling, or floor construction, completely seal voids with fire rated material in accordance with latest approved materials and methods, to full thickness of the penetrated element.

4.05 PAINTING AND CLEANING

A. Touch up panelboards and other items of electrical equipment not “finish painted” under other sections if finished surface is marred or damaged. Use paint furnished by the equipment manufacturer specifically for that purpose.

B. Leave all equipment, lighting fixtures, etc., in clean condition, with all unnecessary labels removed. Use cleaning materials appropriate to the surface and material being cleaned.

C. Clean up and remove all electrical construction debris from the site both prior to final project assessment and after completion of the work.

4.06 STARTING SYSTEMS

A. Coordinate schedule for start-up of various equipment and systems with Architect, Engineer, And Project Coordinator.

B. Notify Project Coordinator and Owner seven days prior to start-up of each item.

C. Verify tests, meter readings, and specified electrical characteristics agree with those required by the equipment or system manufacturer.

D. Verify that wiring and support components for equipment are complete and tested.

E. Execute start-up under supervision of applicable Contractor personnel and manufacturer’s representative in accordance with manufacturers' instructions.

F. When specified in individual Specification Sections, Contractor to require that equipment manufacturer provide authorized representative to be present at site to inspect, check, and approve equipment or system installation prior to start-up, and to supervise placing equipment or system in operation.

G. Submit a written report that equipment or system has been properly installed and is functioning correctly.

H. Adjust operating products and equipment to ensure smooth and unhindered operation. Refer to individual sections for additional adjustment requirements.

PART 5 - CLOSE OUT REQUIREMENTS

5.01 CLOSEOUT PROCEDURES

A. Notify Project Coordinator when work is considered ready for Substantial Completion.

B. Provide Substantial Completion Submittals as required by Division 01 and these specifications.

C. Provide close out submittals as required by Division 01 and these specifications.
D. Notify Architect and Project Coordinator when work is considered finally complete.

E. Complete items of work determined by Engineer’s final inspection.

F. Turn over complete, legible, set of “red-line” line documents accurately reflecting as-constructed changes to design layouts.

5.02 TESTING AND DEMONSTRATIONS

A. Test and demonstrate that all electrical equipment and systems operate in accordance with the requirements of the Contract Documents and manufacturer’s instructions. Repair or replace any equipment or system that fails the tests and demonstrations.

B. Demonstrate operation and maintenance of products to Owner’s personnel two weeks prior to date of Substantial Completion.

C. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at scheduled time, at equipment location.

D. For equipment or systems requiring seasonal operation, perform demonstration for other season within six months.

E. Provide a qualified person who is knowledgeable about the Project to perform demonstration and instruction of owner personnel.

F. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with Owner’s personnel in detail to explain all aspects of operation and maintenance.

G. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.

5.03 OPERATING AND MAINTENANCE MANUALS

A. Submit Operating and Maintenance Manuals for the following equipment. Include, as a minimum, all information incorporated in the submittals.

1. Lighting Fixtures
2. Emergency lighting power system.
3. Panelboards and Switchboards
4. Lighting Control Equipment (Timeclock, Photocell, Relays, Switches, and Enclosure)
5. Fuses and Connector Kits
6. Wiring Devices
7. Safety Switches and Disconnects

B. Make up required operating and maintenance manuals no later than two weeks prior to completion of the project.

C. Include warranties, description of required testing and testing methods and details of routine maintenance.

D. Include recommended replacement parts with names, addresses, and telephone numbers of service organizations that carry the parts in stock.

E. Manuals shall be 8.5x11, bound in hard back binder, suitably labeled for identification. Accordion fold larger sheets to this size. Provide index page and plastic tabs coordinated with the index.

F. Submit one copy of the manual to the Engineer for review, and after review make noted changes. Turn over 3 copies of the final manual to the Owner.
G. The Contract is not complete and final payment to the contractor will not be made until final operating and maintenance manuals are received and accepted.

5.04 MAINTENANCE SERVICE

A. Furnish service and maintenance of components indicated in specification sections for 1 year from date of Substantial Completion.

B. Examine system components at a frequency consistent with reliable operation. Clean, adjust, and lubricate as required.

C. Include systematic examination, adjustment, and lubrication of components. Repair or replace parts whenever required. Use parts produced by the manufacturer of the original component.

D. Maintenance service shall not be assigned or transferred to any agent or Subcontractor without prior written consent of the Owner.

END OF SECTION
SECTION 26 0519
CONDUCTORS AND CABLE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Single conductor building wire.
B. Armored cable.
C. Metal-clad cable.
D. Wire and cable for 600 volts and less.
E. Wiring connectors.

1.02 REFERENCE STANDARDS

C. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
D. NECA 104 - Recommended Practice for Installing Aluminum Building Wire and Cable; 2012.
E. NECA 120 - Standard for Installing Armored Cable (AC) and Metal-Clad Cable (MC); 2012.
H. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
I. UL 4 - Armored Cable; Current Edition, Including All Revisions.
K. UL 1569 - Metal-Clad Cables; Current Edition, Including All Revisions.

PART 2 PRODUCTS

2.01 CONDUCTOR AND CABLE APPLICATIONS

A. Do not use conductors and cables for applications other than as permitted by NFPA 70 and product listing.
B. Provide single conductor building wire installed in suitable raceway unless otherwise indicated, permitted, or required.
C. Nonmetallic-sheathed cable is not permitted.
D. Underground feeder and branch-circuit cable is not permitted.
E. Armored cable is permitted only as follows:
1. Where not otherwise restricted, may be used:
   a. Where concealed above accessible ceilings for final connections from junction boxes
to luminaires.
      1) Maximum Length: 6 feet.

F. Metal-clad cable is not permitted.
   1. Where not otherwise restricted, may be used:
      a. Where concealed above accessible ceilings for final connections from junction boxes
to luminaires.
      1) Maximum Length: 6 feet.

G. Concealed Dry Interior Locations: Use only building wire in raceway.
H. Exposed Dry Interior Locations: Use only specified building wire in raceway.
I. Above Accessible Ceilings: Use only building wire in raceway.
J. Wet or Damp Interior Locations: Use only building wire in raceway.
K. Exterior Locations: Use only building wire in raceway.
L. Underground Installations: Use only building wire in raceway.
M. Conductors and Cables Installed in Cable Tray: Listed and labeled as suitable for cable tray use.

2.02 CONDUCTOR AND CABLE GENERAL REQUIREMENTS

A. Provide products that comply with requirements of NFPA 70.
B. Provide products listed, classified, and labeled as suitable for the purpose intended.
C. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring,
   connectors, etc. as required for a complete operating system.
D. Comply with NEMA WC 70.
E. Thermoplastic-Insulated Conductors and Cables: Listed and labeled as complying with UL 83.
F. Thermoset-Insulated Conductors and Cables: Listed and labeled as complying with UL 44.
G. Conductors for Grounding and Bonding: Also comply with Section 26 0526.
H. Conductors and Cables Installed in Cable Tray: Listed and labeled as suitable for cable tray use.
I. Conductors and Cables Installed Exposed in Spaces Used for Environmental Air (only where
   specifically permitted): Plenum rated, listed and labeled as suitable for use in return air plenums.
J. Conductor Material:
   1. Provide copper conductors except where aluminum conductors are specifically indicated or
      permitted for substitution. Conductor sizes indicated are based on copper unless specifically
      indicated as aluminum. Conductors designated with the abbreviation "AL" indicate
      aluminum.
      a. Substitution of aluminum conductors for copper is permitted, when approved by Owner
         and authority having jurisdiction, only for the following:
         1) Services: Copper conductors size 1/0 AWG and larger.
         2) Feeders: Copper conductors size 1/0 AWG and larger.
      b. Where aluminum conductors are substituted for copper, comply with the following:
1) Size aluminum conductors to provide, when compared to copper sizes indicated, equivalent or greater ampacity and equivalent or less voltage drop.

2) Increase size of raceways, boxes, wiring gutters, enclosures, etc. as required to accommodate aluminum conductors.

3) Provide aluminum equipment grounding conductor sized according to NFPA 70.

4) Equip electrical distribution equipment with compression lugs for terminating aluminum conductors.

2. Copper Conductors: Soft drawn annealed, 98 percent conductivity, uncoated copper conductors complying with ASTM B3, ASTM B8, or ASTM B787/B787M unless otherwise indicated.

3. Tinned Copper Conductors: Comply with ASTM B33.

4. Aluminum Conductors (only where specifically indicated or permitted for substitution): AA-8000 series aluminum alloy conductors recognized by ASTM B800 and compact stranded in accordance with ASTM B801 unless otherwise indicated.

K. Minimum Conductor Size:
   1. Branch Circuits: 12 AWG.
      a. Exceptions:
         1) 20 A, 120 V circuits longer than 75 feet: 10 AWG, for voltage drop.
         2) 20 A, 120 V circuits longer than 150 feet: 8 AWG, for voltage drop.
         3) 20 A, 277 V circuits longer than 150 feet: 10 AWG, for voltage drop.
   2. Control Circuits: 14 AWG.

L. Where conductor size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

M. All branch circuits to to be stranded, #10 AWG to first junction box.

N. Conductor Color Coding:
   1. Color code conductors as indicated unless otherwise required by the authority having jurisdiction. Maintain consistent color coding throughout project.
      a. Conductors size 4 AWG and larger may have black insulation color coded using vinyl color coding electrical tape.
   3. Color Code:
      a. 480Y/277 V, 3 Phase, 4 Wire System:
         1) Phase A: Brown.
         2) Phase B: Orange.
         3) Phase C: Yellow.
         4) Neutral/Grounded: Gray.
      b. 208Y/120 V, 3 Phase, 4 Wire System:
         1) Phase A: Black.
         2) Phase B: Red.
         3) Phase C: Blue.
         4) Neutral/Grounded: White.
      c. Equipment Ground, All Systems: Green.
      d. Travelers for 3-Way and 4-Way Switching: Purple.

2.03 SINGLE CONDUCTOR BUILDING WIRE

A. Description: Single conductor insulated wire.
B. Conductor Stranding:
   1. Feeders and Branch Circuits:
      b. Size 8 AWG and Larger: Stranded.

C. Insulation:
   1. Building Cable/Wire: Type THHN/THWN or THHN/THWN-2.

D. Conductor: Copper.

E. Insulation Voltage Rating: 600 volts.

2.04 ARMORED CABLE

A. Description: NFPA 70, Type AC cable listed and labeled as complying with UL 4, and listed for use in classified firestop systems to be used.

B. Conductor Stranding:
   1. Size 10 AWG and Smaller: Stranded.
   2. Size 8 AWG and Larger: Stranded.

C. Insulation Voltage Rating: 600 V.

D. Insulation: Type THHN.

E. Grounding: Combination of interlocking armor and integral bonding wire.

F. Armor: Steel, interlocked tape.

2.05 METAL-CLAD CABLE

A. Description: NFPA 70, Type MC cable listed and labeled as complying with UL 1569, and listed for use in classified firestop systems to be used.

B. Conductor Stranding:
   1. Size 10 AWG and Smaller: Stranded.
   2. Size 8 AWG and Larger: Stranded.

C. Insulation Voltage Rating: 600 volts.

D. Insulation: Type THHN, THHN/THWN, or THHN/THWN-2.

E. Grounding: Full-size integral equipment grounding conductor.

F. Armor: Steel, interlocked tape.

2.06 WIRING CONNECTORS

A. Description: Wiring connectors appropriate for the application, suitable for use with the conductors to be connected, and listed as complying with UL 486A-486B or UL 486C as applicable.

B. Connectors for Grounding and Bonding: Comply with Section 26 0526.

C. Wiring Connectors for Splices and Taps:
   1. Copper Conductors Size 8 AWG and Smaller: Use twist-on insulated spring connectors.
   2. Copper Conductors Size 6 AWG and Larger: Use mechanical connectors or compression connectors.
D. Wiring Connectors for Terminations:
   1. Provide terminal lugs for connecting conductors to equipment furnished with terminations
designed for terminal lugs.
   2. Where over-sized conductors are larger than the equipment terminations can
   accommodate, provide connectors suitable for reducing to appropriate size, but not less
   than required for the rating of the overcurrent protective device.
   3. Provide motor pigtail connectors for connecting motor leads in order to facilitate
disconnection.

E. Do not use push-in wire connectors as a substitute for twist-on insulated spring connectors.

F. Twist-on Insulated Spring Connectors: Rated 600 V, 221 degrees F for standard applications and
   302 degrees F for high temperature applications; pre-filled with sealant and listed as complying
   with UL 486D for damp and wet locations.

G. Mechanical Connectors: Provide bolted type or set-screw type.

H. Compression Connectors: Provide circumferential type or hex type crimp configuration.

PART 3 EXECUTION

3.01 EXAMINATION
   A. Verify that interior of building has been protected from weather.
   B. Verify that work likely to damage wire and cable has been completed.
   C. Verify that raceways, boxes, and equipment enclosures are installed and are properly sized to
   accommodate conductors and cables in accordance with NFPA 70.
   D. Verify that raceway installation is complete and supported.
   E. Verify that conditions are satisfactory for installation prior to starting work.

3.02 PREPARATION
   A. Clean raceways thoroughly to remove foreign materials before installing conductors and cables.

3.03 INSTALLATION
   A. Circuiting Requirements:
      1. Unless dimensioned, circuit routing indicated is diagrammatic.
      2. When circuit destination is indicated without specific routing, determine exact routing
         required.
      3. Arrange circuiting to minimize splices.
      4. Include circuit lengths required to install connected devices within 10 ft of location indicated.
      5. Maintain separation of Class 1, Class 2, and Class 3 remote-control, signaling, and
         power-limited circuits in accordance with NFPA 70.
      6. Maintain separation of wiring for emergency systems in accordance with NFPA 70.
      7. Circuiting Adjustments: Unless otherwise indicated, when branch circuits are indicated as
         separate, combining them together in a single raceway is not permitted.
      8. Common Neutrals: Unless otherwise indicated, sharing of neutral/grounded conductors
         among up to three single phase branch circuits of different phases installed in the same
         raceway is not permitted. Provide dedicated neutral/grounded conductor for each individual
         branch circuit.
B. Install products in accordance with manufacturer’s instructions.

C. Perform work in accordance with NECA 1 (general workmanship).

D. Install aluminum conductors in accordance with NECA 104.

E. Install armored cable (Type AC) in accordance with NECA 120.

F. Installation in Raceway:
   1. Tape ends of conductors and cables to prevent infiltration of moisture and other contaminants.
   2. Pull all conductors and cables together into raceway at same time.
   3. Do not damage conductors and cables or exceed manufacturer’s recommended maximum pulling tension and sidewall pressure.
   4. Use suitable wire pulling lubricant where necessary, except when lubricant is not recommended by the manufacturer.

G. Paralleled Conductors: Install conductors of the same length and terminate in the same manner.

H. Secure and support conductors and cables in accordance with NFPA 70 using suitable supports and methods approved by the authority having jurisdiction. Provide independent support from building structure. Do not provide support from raceways, piping, ductwork, or other systems.
   1. Installation Above Suspended Ceilings: Do not provide support from ceiling support system. Do not provide support from ceiling grid or allow conductors and cables to lay on ceiling tiles.

I. Terminate cables using suitable fittings.
   1. Armored Cable (Type AC):
      a. Use listed fittings and anti-short, insulating bushings.
      b. Cut cable armor only using specialized tools to prevent damaging conductors or insulation. Do not use hacksaw or wire cutters to cut armor.
   2. Metal-Clad Cable (Type MC):
      a. Use listed fittings.
      b. Cut cable armor only using specialized tools to prevent damaging conductors or insulation. Do not use hacksaw or wire cutters to cut armor.

J. Install conductors with a minimum of 12 inches of slack at each outlet.

K. Where conductors are installed in enclosures for future termination by others, provide a minimum of 5 feet of slack.

L. Neatly train and bundle conductors inside boxes, wireways, panelboards and other equipment enclosures.

M. Group or otherwise identify neutral/grounded conductors with associated ungrounded conductors inside enclosures in accordance with NFPA 70.

N. Make wiring connections using specified wiring connectors.
   1. Make splices and taps only in accessible boxes. Do not pull splices into raceways or make splices in conduit bodies or wiring gutters.
   2. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors.
   3. Do not remove conductor strands to facilitate insertion into connector.
   4. Clean contact surfaces on conductors and connectors to suitable remove corrosion, oxides, and other contaminates. Do not use wire brush on plated connector surfaces.
5. Connections for Aluminum Conductors: Fill connectors with oxide inhibiting compound where not pre-filled by manufacturer.

6. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.

7. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.

O. Insulate splices and taps that are made with uninsulated connectors using methods suitable for the application, with insulation and mechanical strength at least equivalent to unspliced conductors.

1. Dry Locations: Use insulating covers specifically designed for the connectors, electrical tape, or heat shrink tubing.
   a. For taped connections, first apply adequate amount of rubber splicing electrical tape or electrical filler tape, followed by outer covering of vinyl insulating electrical tape.
   b. For taped connections likely to require re-entering, including motor leads, first apply varnished cambric electrical tape, followed by adequate amount of rubber splicing electrical tape, followed by outer covering of vinyl insulating electrical tape.

2. Damp Locations: Use insulating covers specifically designed for the connectors, electrical tape, or heat shrink tubing.
   a. For connections with insulating covers, apply outer covering of moisture sealing electrical tape.
   b. For taped connections, follow same procedure as for dry locations but apply outer covering of moisture sealing electrical tape.


P. Insulate ends of spare conductors using twist-on insulated spring connectors

Q. Field-Applied Color Coding: Where vinyl color coding electrical tape is used in lieu of integrally colored insulation as permitted in Part 2 under "Color Coding", apply half overlapping turns of tape at each termination and at each location conductors are accessible.

R. Install firestopping to preserve fire resistance rating of partitions and other elements, using approved materials and methods.

S. Unless specifically indicated to be excluded, provide final connections to all equipment and devices, including those furnished by others, as required for a complete operating system.

T. Use wiring methods indicated.

U. Protect exposed cable from damage.

V. Support cables above accessible ceiling, using spring metal clips or metal cable ties to support cables from structure or ceiling suspension system. Do not rest cable on ceiling panels.

W. Use suitable cable fittings and connectors.

X. Neatly train and lace wiring inside boxes, equipment, and panelboards.

Y. Clean conductor surfaces before installing lugs and connectors.

Z. Make splices, taps, and terminations to carry full ampacity of conductors with no perceptible temperature rise.

AA. Identify and color code wire and cable under provisions of Section 26 0553. Identify each conductor with its circuit number or other designation indicated.
AB. Do not install or otherwise handle thermoplastic-insulated conductors at temperatures lower than 14 degrees F, unless otherwise permitted by manufacturer's instructions. When installation below this temperature is unavoidable, notify Architect and obtain direction before proceeding with work.

AC. This contractor shall derate conductor ampacity in areas of high ambient temperature per the NEC.

3.04 FIELD QUALITY CONTROL

A. Provide all test results to Engineer in Substantial Completion Submittals, via Architect, prior to scheduling Substantial Completion observations. Test results shall be tabulated to show name of tested device, measured value, expected values, acceptable standard deviation, and test conditions, as well as any miscellaneous variables that may be applicable to test being performed.

B. Perform inspections and tests listed in NETA ATS, Section 7.3.2. The insulation resistance test is only required for services and feeders. The resistance test for parallel conductors listed as optional is not required.
   1. Disconnect surge protective devices (SPDs) prior to performing any high potential testing. Replace SPDs damaged by performing high potential testing with SPDs connected.

C. Correct deficiencies and replace damaged or defective conductors and cables.

END OF SECTION
SECTION 26 0526
GROUNDING AND BONDING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Grounding and bonding requirements.
B. Conductors for grounding and bonding.
C. Connectors for grounding and bonding.
D. Grounding and bonding components.

1.02 REFERENCE STANDARDS

A. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
C. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Verify exact locations of underground metal water service pipe entrances to building.
   2. Coordinate the work with other trades to provide steel reinforcement complying with specified requirements for concrete-encased electrode.

PART 2 PRODUCTS

2.01 GROUNDING AND BONDING REQUIREMENTS

A. Do not use products for applications other than as permitted by NFPA 70 and product listing.
B. Unless specifically indicated to be excluded, provide all required components, conductors, connectors, conduit, boxes, fittings, supports, accessories, etc. as necessary for a complete grounding and bonding system.
C. Where conductor size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
D. Grounding Electrode System:
   1. Provide connection to required and supplemental grounding electrodes indicated to form grounding electrode system.
      a. Provide continuous grounding electrode conductors without splice or joint.
      b. Install grounding electrode conductors in raceway where exposed to physical damage. Bond grounding electrode conductor to metallic raceways at each end with bonding jumper.
   2. Concrete-Encased Electrode:
      a. Provide connection to concrete-encased electrode consisting of not less than 20 feet of either steel reinforcing bars or bare copper conductor not smaller than 4 AWG
embedded within concrete foundation or footing that is in direct contact with earth in accordance with NFPA 70.

E. Bonding and Equipment Grounding:
1. Provide bonding for equipment grounding conductors, equipment ground busses, metallic equipment enclosures, metallic raceways and boxes, device grounding terminals, and other normally non-current-carrying conductive materials enclosing electrical conductors/equipment or likely to become energized as indicated and in accordance with NFPA 70.
2. Provide insulated equipment grounding conductor in each feeder and branch circuit raceway. Do not use raceways as sole equipment grounding conductor.
3. Where circuit conductor sizes are increased for voltage drop, increase size of equipment grounding conductor proportionally in accordance with NFPA 70.
4. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
5. Terminate branch circuit equipment grounding conductors on solidly bonded equipment ground bus only. Do not terminate on neutral (grounded) or isolated/insulated ground bus.
6. Provide bonding jumper across expansion or expansion/deflection fittings provided to accommodate conduit movement.
7. Provide bonding for interior metal piping systems in accordance with NFPA 70. This includes, but is not limited to:
   a. Metal water piping where not already effectively bonded to metal underground water pipe used as grounding electrode.
   b. Metal gas piping.

2.02 GROUNDING AND BONDING COMPONENTS

A. General Requirements:
1. Provide products listed, classified, and labeled as suitable for the purpose intended.
2. Provide products listed and labeled as complying with UL 467 where applicable.

B. Conductors for Grounding and Bonding, in Addition to Requirements of Section 26 0526:
1. Use insulated copper conductors unless otherwise indicated.
   a. Exceptions:
      1) Use bare copper conductors where installed underground in direct contact with earth.
      2) Use bare copper conductors where directly encased in concrete (not in raceway).

C. Connectors for Grounding and Bonding:
1. Description: Connectors appropriate for the application and suitable for the conductors and items to be connected; listed and labeled as complying with UL 467.
2. Unless otherwise indicated, use exothermic welded connections for underground, concealed and other inaccessible connections.
3. Unless otherwise indicated, use mechanical connectors or compression connectors for accessible connections.
   a. Exceptions:

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that work likely to damage grounding and bonding system components has been completed.
B. Verify that conditions are satisfactory for installation prior to starting work.
C. Verify that final backfill and compaction has been completed before driving rod electrodes.

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions.
B. Perform work in accordance with NECA 1 (general workmanship).
C. Make grounding and bonding connections using specified connectors.
   1. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors. Do not remove conductor strands to facilitate insertion into connector.
   2. Remove nonconductive paint, enamel, or similar coating at threads, contact points, and contact surfaces.
   3. Exothermic Welds: Make connections using molds and weld material suitable for the items to be connected in accordance with manufacturer's recommendations.
   4. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
   5. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.
D. Identify grounding and bonding system components in accordance with Section 26 0553.
E. Provide grounding electrode conductor and connect to reinforcing steel in foundation footing. Bond steel together.
F. Equipment Grounding Conductor: Provide separate, insulated copper equipment grounding conductor in all conduits and raceways described below. Terminate each end on suitable lug, bus, or bushing. Where ground conductors are specified or required, conduit sizes shall be increased as necessary to meet the NEC conduit fill requirements.
   1. All new feeders.
   2. All raceways for receptacle circuits, including special power receptacles.
   3. All surface raceway/multi-outlet assemblies containing power receptacles (i.e. wiremold).
   4. All motor feeders and branch circuits.
   5. All flexible metal conduit.
   6. All non-metallic raceways containing power conductors.
G. Provide separate, insulated conductor within all raceways or sections of raceways which contain non-metallic conduit.
H. Provide separate grounding jumper from the grounding screw of all receptacle devices to the metallic box in which device is mounted. Jumper may attach to box with a separate grounding screw or clip device. Jumpers may be eliminated if approved self-grounding devices are used.
I. In general, equipment grounding conductors are not indicated on the plans. Size conductors to comply with NEC requirements.

3.03 FIELD QUALITY CONTROL

A. Provide all test results to Engineer in Substantial Completion Submittals, via Architect, prior to scheduling Substantial Completion observations. Test results shall be tabulated to show name of tested device, measured value, expected values, acceptable standard deviation, and test conditions, as well as any miscellaneous variables that may be applicable to test being performed.
B. Perform inspections and tests listed in NETA ATS, Section 7.13.

C. Perform ground electrode resistance tests under normally dry conditions. Precipitation within the previous 48 hours does not constitute normally dry conditions.

D. Investigate and correct deficiencies where measured ground resistances do not comply with specified requirements.

END OF SECTION
SECTION 26 0529
HANGERS AND SUPPORTS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Support and attachment requirements and components for equipment, conduit, cable, boxes, and other electrical work.

1.02 REFERENCE STANDARDS


D. MFMA-4 - Metal Framing Standards Publication; 2004.

E. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

F. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
   2. Coordinate the work with other trades to provide additional framing and materials required for installation.
   3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
   4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.

B. Sequencing:
   1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Section 03 3000.

PART 2 PRODUCTS

2.01 SUPPORT AND ATTACHMENT COMPONENTS

A. General Requirements:
   1. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of electrical work.
   2. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.
   3. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported with a minimum safety factor of 2.5. Include consideration for vibration, equipment operation, and shock loads where applicable.
   4. Do not use products for applications other than as permitted by NFPA 70 and product listing.
5. Do not use wire, chain, or perforated pipe strap for permanent supports unless specifically indicated or permitted.

   a. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel, stainless steel, or approved equivalent unless otherwise indicated.
   b. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
   c. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.

B. Conduit and Cable Supports: Straps, clamps, etc. suitable for the conduit or cable to be supported.
   1. Conduit Straps: One-hole or two-hole type; steel.
   2. Conduit Clamps: Bolted type unless otherwise indicated.

C. Outlet Box Supports: Hangers, brackets, etc. suitable for the boxes to be supported.

D. Metal Channel (Strut) Framing Systems: Factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.
   2. Channel Material:
      a. Indoor Dry Locations: Use painted steel, zinc-plated steel, or galvanized steel.
      b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel.

E. Hanger Rods: Threaded zinc-plated steel unless otherwise indicated.
   1. Minimum Size, Unless Otherwise Indicated or Required:
      a. Equipment Supports: 1/2 inch diameter.
      b. Busway Supports: 1/2 inch diameter.
      c. Single Conduit up to 1 inch (27 mm) trade size: 1/4 inch diameter.
      d. Single Conduit larger than 1 inch (27 mm) trade size: 3/8 inch diameter.
      e. Trapeze Support for Multiple Conduits: 3/8 inch diameter.
      f. Outlet Boxes: 1/4 inch diameter.
      g. Luminaires: 1/4 inch diameter.

F. Non-Penetrating Rooftop Supports for Low-Slope Roofs: Steel pedestals with thermoplastic or rubber bases that rest on top of roofing membrane, not requiring any attachment to the roof structure and not penetrating the roofing assembly, with support fixtures as specified.
   1. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
   2. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports.
   3. Mounting Height: Provide minimum clearance of 12 inches under supported component to top of roofing.

G. Anchors and Fasteners:
   1. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.
   2. Concrete: Use preset concrete inserts, expansion anchors, or screw anchors.
   3. Solid or Grout-Filled Masonry: Use expansion anchors or screw anchors.
   6. Steel: Use beam clamps, machine bolts, or welded threaded studs.
7.  Sheet Metal: Use sheet metal screws.
8.  Wood: Use wood screws.
9.  Plastic and lead anchors are not permitted.
10. Powder-actuated fasteners are not permitted.
11. Hammer-driven anchors and fasteners are not permitted.
12. Preset Concrete Inserts: Continuous metal channel (strut) and spot inserts specifically designed to be cast in concrete ceilings, walls, and floors.
   b. Channel Material: Use galvanized steel.
   c. Manufacturer: Same as manufacturer of metal channel (strut) framing system.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturer's instructions.
B. Perform work in accordance with NECA 1 (general workmanship).
C. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
D. Unless specifically indicated or approved by Architect, do not provide support from suspended ceiling support system or ceiling grid.
E. Unless specifically indicated or approved by Architect, do not provide support from roof deck.
F. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
G. Equipment Support and Attachment:
   1. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.
   2. Use metal channel (strut) secured to studs to support equipment surface-mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
   3. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
   4. Unless otherwise indicated, mount floor-mounted equipment on properly sized 3 inch high concrete pad constructed in accordance with Section 03 3000.
   5. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
   6. Mount floor-mounted equipment on properly sized four (4) inch high concrete pad. Pads provided under Section 03 3000.
H. Preset Concrete Inserts: Use manufacturer provided closure strips to inhibit concrete seepage during concrete pour.
I. Secure fasteners according to manufacturer's recommended torque settings.
J. Remove temporary supports.

3.02 FIELD QUALITY CONTROL

A. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.

END OF SECTION
SECTION 26 0533
CONDUIT FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Galvanized steel rigid metal conduit (GRC).
B. Flexible metal conduit (FMC).
C. Liquidtight flexible metal conduit (LFMC).
D. Electrical metallic tubing (EMT).
E. Rigid polyvinyl chloride conduit (PVC).
F. Accessories.
G. Conduit, fittings and conduit bodies.

1.02 REFERENCE STANDARDS

A. ANSI C80.1 - American National Standard for Electrical Rigid Steel Conduit (ERSC); 2005.
B. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
C. NECA 101 - Standard for Installing Steel Conduits (Rigid, IMC, EMT); 2013.
D. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable; 2012.
E. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
F. UL 6 - Electrical Rigid Metal Conduit-Steel; Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate minimum sizes of conduits with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
   2. Coordinate the arrangement of conduits with structural members, ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
   3. Verify exact conduit termination locations required for boxes, enclosures, and equipment installed under other sections or by others.
   4. Coordinate the work with other trades to provide roof penetrations that preserve the integrity of the roofing system and do not void the roof warranty.
   5. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

B. Sequencing:
   1. Do not begin installation of conductors and cables until installation of conduit is complete between outlet, junction and splicing points.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store conduit and fittings in accordance with manufacturer's instructions.
B. Accept conduit on site. Inspect for damage.

C. Protect conduit from corrosion and entrance of debris by storing above grade. Provide appropriate covering.

D. Protect PVC conduit from sunlight.

**PART 2 PRODUCTS**

**2.01 CONDUIT APPLICATIONS**

A. Do not use conduit and associated fittings for applications other than as permitted by NFPA 70 and product listing.

B. Unless otherwise indicated and where not otherwise restricted, use the conduit types indicated for the specified applications. Where more than one listed application applies, comply with the most restrictive requirements. Where conduit type for a particular application is not specified, use galvanized steel rigid metal conduit.

C. Underground:
   1. Under Slab on Grade: Use galvanized steel rigid metal conduit or rigid PVC conduit.
   2. Exterior, Direct-Buried: Use galvanized steel rigid metal conduit or rigid PVC conduit.
   3. Where rigid polyvinyl (PVC) conduit is provided, transition to galvanized steel rigid metal conduit where emerging from underground.
   4. Where rigid polyvinyl (PVC) conduit larger than 2 inch (53 mm) trade size is provided, use galvanized steel rigid metal conduit elbows for bends.

D. Embedded Within Concrete:
   1. Within Slab on Grade: Not permitted.
   2. Within Concrete Walls Above Ground: Use galvanized steel rigid metal conduit or rigid PVC conduit.
   3. Where rigid polyvinyl (PVC) conduit is provided, transition to galvanized steel rigid metal conduit where emerging from concrete.

E. Concealed Within Masonry Walls: Use galvanized steel rigid metal conduit or electrical metallic tubing (EMT).

F. Concealed Within Hollow Stud Walls: Use galvanized steel rigid metal conduit or electrical metallic tubing (EMT).

G. Concealed Above Accessible Ceilings: Use galvanized steel rigid metal conduit or electrical metallic tubing (EMT).

H. Interior, Damp or Wet Locations: Use galvanized steel rigid metal conduit.

I. Exposed, Interior, Not Subject to Physical Damage: Use electrical metallic tubing (EMT).

J. Exposed, Interior, Subject to Physical Damage: Use galvanized steel rigid metal conduit.
   1. Locations subject to physical damage include, but are not limited to:
      a. Where exposed below 8 feet, except within electrical and communication rooms or closets.

K. Exposed, Interior in utility areas or areas with open ceilings: Use electrical metallic tubing (EMT).

L. Exposed, Exterior: Use galvanized steel rigid metal conduit.
M. Concealed, Exterior, Not Embedded in Concrete or in Contact With Earth: Use galvanized steel rigid metal conduit.

N. Connections to Luminaires Above Accessible Ceilings: Use flexible metal conduit.
   1. Maximum Length: 6 feet.

O. Connections to Vibrating Equipment:
   1. Dry Locations: Use flexible metal conduit.
   2. Damp, Wet, or Corrosive Locations: Use liquidtight flexible metal conduit.
   3. Maximum Length: 6 feet unless otherwise indicated.
   4. Vibrating equipment includes, but is not limited to:
      a. Transformers.
      b. Motors.

2.02 CONDUIT REQUIREMENTS

A. Electrical Service Conduits: Also comply with Section 26 2100.

B. Communications Systems Conduits: Also comply with Section 27 1000.

C. Fittings for Grounding and Bonding: Also comply with Section 26 0526.

D. Provide all conduit, fittings, supports, and accessories required for a complete raceway system.

E. Provide products listed, classified, and labeled as suitable for the purpose intended.

F. Minimum Conduit Size, Unless Otherwise Indicated:
   1. Branch Circuits: 1/2 inch (16 mm) trade size.
   2. Branch Circuit Homers: 3/4 inch (21 mm) trade size.
   3. Flexible Connections to Luminaires: 3/8 inch (12 mm) trade size.
   5. Underground, Exterior: 1 inch (27 mm) trade size.

G. Where conduit size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

H. Provide separate raceways for 208/120V wiring and 480/277V wiring.

2.03 GALVANIZED STEEL RIGID METAL CONDUIT (GRC)

A. Description: NFPA 70, Type RMC galvanized steel rigid metal conduit complying with ANSI C80.1 and listed and labeled as complying with UL 6.

B. Fittings:
   1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
   3. Connectors and Couplings: Use threaded type fittings only. Threadless set screw and compression (gland) type fittings are not permitted.

2.04 FLEXIBLE METAL CONDUIT (FMC)

A. Description: NFPA 70, Type FMC standard wall steel flexible metal conduit listed and labeled as complying with UL 1, and listed for use in classified firestop systems to be used.

B. Fittings:
1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
2. Material: Use material to match conduit.

2.05 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)

A. Description: NFPA 70, Type LFMC polyvinyl chloride (PVC) jacketed steel flexible metal conduit listed and labeled as complying with UL 360.

B. Fittings:
   1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
   2. Material: Use material to match conduit.

2.06 ELECTRICAL METALLIC TUBING (EMT)

A. Description: NFPA 70, Type EMT steel electrical metallic tubing complying with ANSI C80.3 and listed and labeled as complying with UL 797.

B. Fittings:
   1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
   2. Material: Use material to match conduit.
      a. Do not use indenter type connectors and couplings.
      b. Do not use die-cast EMT fittings.
   4. Damp or Wet Locations (where permitted): Use fittings listed for use in wet locations.

2.07 RIGID POLYVINYL CHLORIDE (PVC) CONDUIT

A. Description: NFPA 70, Type PVC rigid polyvinyl chloride conduit complying with NEMA TC 2 and listed and labeled as complying with UL 651; Schedule 40 unless otherwise indicated, Schedule 80 where subject to physical damage; rated for use with conductors rated 90 degrees C.

B. Fittings:
   1. Manufacturer: Same as manufacturer of conduit to be connected.
   2. Description: Fittings complying with NEMA TC 3 and listed and labeled as complying with UL 651; material to match conduit.

2.08 ACCESSORIES

A. Conduit Joint Compound: Corrosion-resistant, electrically conductive; suitable for use with the conduit to be installed.

B. Solvent Cement for PVC Conduit and Fittings: As recommended by manufacturer of conduit and fittings to be installed.

C. Pull Strings: Use nylon cord with average breaking strength of not less than 200 pound-force.

D. Sealing Compound for Sealing Fittings: Listed for use with the particular fittings to be installed.

E. Modular Seals for Conduit Penetrations: Rated for minimum of 40 psig; Suitable for the conduits to be installed.
PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that mounting surfaces are ready to receive conduits.
B. Verify that conditions are satisfactory for installation prior to starting work.
C. Verify routing and termination locations of conduit prior to rough-in.
D. Conduit routing is shown on drawings is in approximate location unless dimensioned. Route as required to complete wiring system.

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions.
B. Perform work in accordance with NECA 1 (general workmanship).
C. Install galvanized steel rigid metal conduit (GRC) in accordance with NECA 101.
D. Install rigid polyvinyl chloride (PVC) conduit in accordance with NECA 111.
E. Conduit Routing:
   1. Unless dimensioned, conduit routing indicated is diagrammatic.
   2. When conduit destination is indicated without specific routing, determine exact routing required.
   3. Conceal all conduits unless specifically indicated to be exposed.
   4. Conduits in the following areas may be exposed, unless otherwise indicated:
      a. Electrical rooms.
      b. Mechanical equipment rooms.
      c. Within joists in areas with no ceiling.
         1) Coordinate routing in joist with mechanical duct work to avoid conflicts.
   5. Unless otherwise approved, do not route conduits exposed:
      a. Across floors.
      b. Across roofs.
      c. Across top of parapet walls.
      d. Across building exterior surfaces.
   6. Conduits installed underground may be routed in the shortest possible manner unless otherwise indicated. Route all other conduits parallel or perpendicular to building structure and surfaces, following surface contours where practical.
   7. Arrange conduit to maintain adequate headroom, clearances, and access.
   8. Arrange conduit to provide no more than the equivalent of four 90 degree bends between pull points.
   9. Route conduits above water and drain piping where possible.
  10. Arrange conduit to prevent moisture traps. Provide drain fittings at low points and at sealing fittings where moisture may collect.
  11. Maintain minimum clearance of 12 inches between conduits and hot surfaces. This includes, but is not limited to:
       a. Heaters.
       b. Hot water piping.
       c. Flues.
  12. Group parallel conduits in the same area together on a common rack.
F. Conduit Support:
1. Secure and support conduits in accordance with NFPA 70 and Section 26 0529 using suitable supports and methods approved by the authority having jurisdiction.
2. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
3. Installation Above Suspended Ceilings: Do not provide support from ceiling support system. Do not provide support from ceiling grid or allow conduits to lay on ceiling tiles.
4. Use conduit strap to support single surface-mounted conduit.
   a. Use clamp back spacer with conduit strap for damp and wet locations to provide space between conduit and mounting surface.
5. Use metal channel (strut) with accessory conduit clamps to support multiple parallel surface-mounted conduits.
6. Use conduit clamp to support single conduit from beam clamp or threaded rod.
7. Use trapeze hangers assembled from threaded rods and metal channel (strut) with accessory conduit clamps to support multiple parallel suspended conduits.
8. Use non-penetrating rooftop supports to support conduits routed across rooftops (only where approved).
9. Use of wire for support of conduits is not permitted.
10. Support conduit using coated steel strap, clevis hanger, split hanger, or lay-in adjustable hangers.

G. Connections and Terminations:
1. Use approved zinc-rich paint or conduit joint compound on field-cut threads of galvanized steel conduits prior to making connections.
2. Where two threaded conduits must be joined and neither can be rotated, use three-piece couplings or split couplings. Do not use running threads.
3. Use suitable adapters where required to transition from one type of conduit to another.
4. Provide drip loops for liquidtight flexible conduit connections to prevent drainage of liquid into connectors.
5. Terminate threaded conduits in boxes and enclosures using threaded hubs or double lock nuts for dry locations and raintight hubs for wet locations.
6. Provide insulating bushings or insulated throats at all conduit terminations to protect conductors.
7. Secure joints and connections to provide maximum mechanical strength and electrical continuity.

H. Penetrations:
1. Do not penetrate or otherwise notch or cut structural members, including footings and grade beams, without approval of Structural Engineer.
2. Make penetrations perpendicular to surfaces unless otherwise indicated.
3. Provide sleeves for penetrations as indicated or as required to facilitate installation. Set sleeves flush with exposed surfaces unless otherwise indicated or required.
4. Conceal bends for conduit risers emerging above ground.
5. Seal interior of conduits entering the building from underground at first accessible point to prevent entry of moisture and gases.
6. Provide suitable modular seal where conduits penetrate exterior wall below grade.
7. Where conduits penetrate waterproof membrane, seal as required to maintain integrity of membrane.
8. Make penetrations for roof-mounted equipment within associated equipment openings and curbs where possible to minimize roofing system penetrations. Where penetrations are necessary, seal as indicated or as required to preserve integrity of roofing system and...
maintain roof warranty. Include proposed locations of penetrations and methods for sealing with submittals.

9. Provide metal escutcheon plates for conduit penetrations exposed to public view.

10. Install firestopping to preserve fire resistance ratings of partitions and other elements, using materials and methods approved under the fire protection specifications.

I. Underground Installation:
   1. Provide trenching and backfilling in accordance with Section 31 2316 and Section 31 2323.
   2. Minimum Cover, Unless Otherwise Indicated or Required:
      b. Under Slab on Grade: 12 inches to bottom of slab.
   3. Provide underground warning tape in accordance with Section 26 0553 along entire conduit length.

J. Conduit Movement Provisions: Where conduits are subject to movement, provide expansion and expansion/deflection fittings to prevent damage to enclosed conductors or connected equipment. This includes, but is not limited to:
   1. Where conduits cross structural joints intended for expansion, contraction, or deflection.
   2. Where calculated in accordance with NFPA 70 for rigid polyvinyl chloride (PVC) conduit installed above ground to compensate for thermal expansion and contraction.
   3. Where conduits are subject to earth movement by settlement or frost.
   4. Where specifically called out on drawings.

K. Condensation Prevention: Where conduits cross barriers between areas of potential substantial temperature differential, provide sealing fitting or approved sealing compound at an accessible point near the penetration to prevent condensation. This includes, but is not limited to:
   1. Where conduits pass from outdoors into conditioned interior spaces.
   2. Where conduits pass from unconditioned interior spaces into conditioned interior spaces.

L. Provide pull string in all empty conduits and in conduits where conductors and cables are to be installed by others. Leave minimum slack of 12 inches at each end.

M. Provide grounding and bonding in accordance with Section 26 0526.

N. Identify conduits in accordance with Section 26 0553.

3.03 FIELD QUALITY CONTROL

A. Perform inspection, testing, and adjusting in accordance with Section 01 4000.

B. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.

C. Correct deficiencies and replace damaged or defective conduits.

END OF SECTION
SECTION 26 0534

BOXES FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Outlet and device boxes up to 100 cubic inches, including those used as junction and pull boxes.
B. Cabinets and enclosures, including junction and pull boxes larger than 100 cubic inches.
C. Floor boxes.
D. Underground boxes/enclosures.
E. Wall and ceiling outlet boxes.
F. Pull and junction boxes.

1.02 REFERENCE STANDARDS

A. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
B. NECA 130 - Standard for Installing and Maintaining Wiring Devices; 2010.
C. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable; 2012.
D. NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports; 2013.
E. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2014.
F. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
   2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
   3. Coordinate minimum sizes of boxes with the actual installed arrangement of conductors, clamps, support fittings, and devices, calculated according to NFPA 70.
   4. Coordinate minimum sizes of pull boxes with the actual installed arrangement of connected conduits, calculated according to NFPA 70.
   5. Coordinate the placement of boxes with millwork, furniture, devices, equipment, etc. installed under other sections or by others.
   6. Coordinate the work with other trades to preserve insulation integrity.
   7. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted boxes where indicated.
   8. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
1.04  SUBMITTALS

A.  See Section 26 0010 - General Electrical Requirements for submittal procedures.

B.  Product Data:  Provide manufacturer’s standard catalog pages and data sheets for cabinets and enclosures and floor boxes.

C.  Maintenance Materials:  Furnish the following for Owner’s use in maintenance of project.
   1.  Keys for Lockable Enclosures:  Two of each different key.
       a.  Deliver to Owner in accordance with Division 01 instructions.

PART 2  PRODUCTS

2.01  BOXES

A.  General Requirements:
   1.  Do not use boxes and associated accessories for applications other than as permitted by NFPA 70 and product listing.
   2.  Provide all boxes, fittings, supports, and accessories required for a complete raceway system and to accommodate devices and equipment to be installed.
   3.  Provide products listed, classified, and labeled as suitable for the purpose intended.
   4.  Where box size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
   5.  Provide grounding terminals within boxes where equipment grounding conductors terminate.

B.  Outlet and Device Boxes Up to 100 cubic inches, Including Those Used as Junction and Pull Boxes:
   1.  Use sheet-steel boxes for dry locations unless otherwise indicated or required.
   2.  Use cast iron boxes for damp or wet locations unless otherwise indicated or required; furnish with compatible weatherproof gasketed covers.
   3.  Use cast iron boxes or cast aluminum boxes where exposed galvanized steel rigid metal conduit is used.
   4.  Use suitable concrete type boxes where flush-mounted in concrete.
   5.  Use suitable masonry type boxes where flush-mounted in masonry walls.
   6.  Use raised covers suitable for the type of wall construction and device configuration where required.
   7.  Use shallow boxes where required by the type of wall construction.
   8.  Do not use “through-wall” boxes designed for access from both sides of wall.
   9.  Sheet-Steel Boxes:  Comply with NEMA OS 1, and list and label as complying with UL 514A.
   10.  Cast Metal Boxes:  Comply with NEMA FB 1, and list and label as complying with UL 514A; furnish with threaded hubs.
   11.  Boxes for Supporting Luminaires and Ceiling Fans:  Listed as suitable for the type and weight of load to be supported; furnished with fixture stud to accommodate mounting of luminaire where required.
   13.  Minimum Box Size, Unless Otherwise Indicated:
       a.  Wiring Devices:  4 inch square by 2-1/8 inch deep (100 by 54 mm) trade size.
       b.  Ceiling Outlets:  4 inch octagonal or square by 2-1/8 inch deep (100 by 54 mm) trade size.
   14.  Wall Plates:  Comply with Section 26 2726.

C.  Cabinets and Enclosures, Including Junction and Pull Boxes Larger Than 100 cubic inches:
1. Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E, or UL 508A.

2. NEMA 250 Environment Type, Unless Otherwise Indicated:
   a. Indoor Clean, Dry Locations: Type 1, painted steel.
   b. Outdoor Locations: Type 3R, painted steel.

3. Junction and Pull Boxes Larger Than 100 cubic inches:
   a. Provide screw-cover or hinged-cover enclosures unless otherwise indicated.
   b. Boxes 6 square feet and Larger: Provide sectionalized screw-cover or hinged-cover enclosures.

4. Cabinets and Hinged-Cover Enclosures, Other Than Junction and Pull Boxes:
   a. Provide lockable hinged covers, all locks keyed alike unless otherwise indicated.
   c. Terminal Blocks: Provide voltage/current ratings and terminal quantity suitable for purpose indicated, with 25 percent spare terminal capacity.

5. Finish for Painted Steel Enclosures: Manufacturer’s standard grey unless otherwise indicated.

D. Floor Boxes:
   1. Description: Floor boxes compatible with floor box service fittings provided in accordance with Section 26 2726; with partitions to separate multiple services; furnished with all components, adapters, and trims required for complete installation.
   2. Use sheet-steel or cast iron floor boxes within slab above grade.
   3. Metallic Floor Boxes: Fully adjustable (with integral means for leveling adjustment prior to and after concrete pour).
   4. Manufacturer: Same as manufacturer of floor box service fittings.

E. Underground Boxes/Enclosures:
   1. Description: In-ground, open bottom boxes furnished with flush, non-skid covers with legend indicating type of service and stainless steel tamper resistant cover bolts.
   2. Size: As indicated on drawings.
   3. Depth: As required to extend below frost line to prevent frost upheaval, but not less than 12 inches.
   4. Applications:
      a. Sidewalks and Landscaped Areas Subject Only to Occasional Nondeliberate Vehicular Traffic: Use polymer concrete enclosures, with minimum SCTE 77, Tier 8 load rating.
      b. Parking Lots, in Areas Subject Only To Occasional Nondeliberate Vehicular Traffic: Use polymer concrete enclosures, with minimum SCTE 77, Tier 15 load rating.
      c. Do not use polymer concrete enclosures in areas subject to deliberate vehicular traffic.
   5. Polymer Concrete Underground Boxes/Enclosures: Comply with SCTE 77.
      a. Combination fiberglass/polymer concrete boxes/enclosures are acceptable.

2.02 PULL AND JUNCTION BOXES

A. Surface Mounted Cast Metal Box: NEMA 250, Type 4; flat-flanged, surface mounted junction box:

B. Fiberglass Handholes: Die molded glass fiber hand holes:
   1. Cable Entrance: Pre-cut 6 x 6 inch cable entrance at center bottom of each side.
   2. Cover: Glass fiber weatherproof cover with nonskid finish.
PART 3 EXECUTION

3.01 EXAMINATION

A. Verify locations of floor boxes and outlets prior to rough-in.

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install boxes in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards where mounting heights are not indicated.

C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.

D. Unless otherwise indicated, provide separate boxes for line voltage and low voltage systems.

E. Unless otherwise indicated, boxes may be surface-mounted where exposed conduits are indicated or permitted.

F. Box Locations:

1. Locate boxes to be accessible. Provide access panels in accordance with Section 08 3100 as required where approved by the Architect.

2. Unless dimensioned, box locations indicated are approximate.

3. Locate boxes as required for devices installed under other sections or by others.

4. Locate boxes so that wall plates do not span different building finishes.

5. Locate boxes so that wall plates do not cross masonry joints.

6. Unless otherwise indicated, where multiple outlet boxes are installed at the same location at different mounting heights, install along a common vertical center line.

7. Do not install flush-mounted boxes on opposite sides of walls back-to-back. Provide minimum 6 inches horizontal separation unless otherwise indicated.

8. Acoustic-Rated Walls: Do not install flush-mounted boxes on opposite sides of walls back-to-back; provide minimum 24 inches horizontal separation.

9. Fire Resistance Rated Walls: Install flush-mounted boxes such that the required fire resistance will not be reduced.
   a. Do not install flush-mounted boxes on opposite sides of walls back-to-back; provide minimum 24 inches separation where wall is constructed with individual noncommunicating stud cavities or protect both boxes with listed putty pads.
   b. Do not install flush-mounted boxes with area larger than 16 square inches or such that the total aggregate area of openings exceeds 100 square inches for any 100 square feet of wall area.

10. Locate junction and pull boxes as indicated, as required to facilitate installation of conductors, and to limit conduit length and/or number of bends between pulling points in accordance with Section 26 0533.

11. Locate junction and pull boxes in the following areas, unless otherwise indicated or approved by the Architect:
   a. Concealed above accessible suspended ceilings.
   b. Within joists in areas with no ceiling.
   c. Electrical rooms.
   d. Mechanical equipment rooms.

G. Box Supports:
1. Secure and support boxes in accordance with NFPA 70 and Section 26 0529 using suitable supports and methods approved by the authority having jurisdiction.

2. Provide independent support, at each corner, from building structure except for cast metal boxes (other than boxes used for fixture support) supported by threaded conduit connections in accordance with NFPA 70. Do not provide support from piping, ductwork, or other systems.

3. Installation Above Suspended Ceilings: Do not provide support from ceiling grid or ceiling support system.

H. Install boxes plumb and level.

I. Flush-Mounted Boxes:
   1. Install boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that front edge of box or associated raised cover is not set back from finished surface more than 1/4 inch or does not project beyond finished surface.
   2. Install boxes in combustible materials such as wood so that front edge of box or associated raised cover is flush with finished surface.
   3. Repair rough openings around boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that there are no gaps or open spaces greater than 1/8 inch at the edge of the box.

J. Install boxes as required to preserve insulation integrity.

K. Metallic Floor Boxes: Install box level at the proper elevation to be flush with finished floor.

L. Underground Boxes/Enclosures:
   1. Install enclosure on gravel base, minimum 6 inches deep.
   2. Flush-mount enclosures located in concrete or paved areas.
   3. Mount enclosures located in landscaped areas with top at 1 inch above finished grade.
   4. Install additional bracing inside enclosures in accordance with manufacturer's instructions to minimize box sidewall deflections during backfilling. Backfill with cover bolted in place.

M. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.

N. Install firestopping to preserve fire resistance rating of partitions and other elements, using approved materials and methods.

O. Close unused box openings.

P. Provide grounding and bonding in accordance with Section 26 0526.

Q. Install in locations as shown on Drawings, and as required for splices, taps, wire pulling, equipment connections, and as required by NFPA 70.

R. Coordinate installation of outlet boxes for equipment connected under Section 26 2717.

S. Electrical boxes are shown on Drawings in approximate locations unless dimensioned.
   1. Adjust box locations up to 10 feet if required to accommodate intended purpose.

T. Orient boxes to accommodate wiring devices oriented as specified in Section 26 2726.

U. Maintain headroom and present neat mechanical appearance.

V. Install pull boxes and junction boxes above accessible ceilings and in unfinished areas only.
W. Inaccessible Ceiling Areas: Install outlet and junction boxes no more than 6 inches from ceiling access panel or from removable recessed luminaire.

X. Align adjacent wall mounted outlet boxes for switches, thermostats, and similar devices.

Y. Secure flush mounting box to interior wall and partition studs. Accurately position to allow for surface finish thickness.

Z. Use stamped steel bridges to fasten flush mounting outlet box between studs.

AA. Install flush mounting box without damaging wall insulation or reducing its effectiveness.

AB. Use adjustable steel channel fasteners for hung ceiling outlet box.

AC. Support boxes independently of conduit, except cast box that is connected to two rigid metal conduits both supported within 12 inches of box.

AD. Use gang box where more than one device is mounted together. Do not use sectional box.

AE. Use gang box with plaster ring for single device outlets.

AF. Use cast outlet box in exterior locations exposed to the weather and wet locations.

AG. Identify boxes in accordance with Section 26 0553.

AH. Locate flush mounting box in masonry wall to require cutting of masonry unit corner only. Coordinate masonry cutting to achieve neat opening.

3.03 ADJUSTING

A. Adjust flush-mounting outlets to make front flush with finished wall material.

B. Install knockout closures in unused box openings.

3.04 CLEANING

A. Clean interior of boxes to remove dirt, debris, plaster and other foreign material.

B. Clean electrical parts to remove conductive and harmful materials.

C. Clean finishes and touch up damage.

END OF SECTION
SECTION 260548
ELECTRICAL NOISE AND VIBRATION CONTROL

PART 1 GENERAL

1.01 SUMMARY

A. This section includes:
   1. Neoprene Pads
   2. Neoprene Mountings and Hangers
   3. Spring Isolation Mounts and Hangers

B. Vibration Control Products furnished as integral part of factory-fabricated equipment are specified as part of equipment assembly in other Division 26 sections.

C. Refer to other Division 26 sections for equipment foundations, hangers, sealants, gaskets, and requirements of electrical connections to equipment isolated on vibration control products.

1.02 NOISE CRITERIA

A. Noise levels due to mechanical or electrical equipment, ductwork, grilles, registers, terminal devices, diffusers, etc., shall not exceed sound pressure levels in all 8 octave bands corresponding to NC levels per ASHRAE handbook as indicated.
   1. Existing and New Holdrooms: NC-35

B. All penetrations by conduit through partitions, floors, and ceilings at spaces listed above, rooms with slab-to-slab acoustical walls, and mechanical and electrical rooms shall be packed with insulation and sealed airtight with non-hardening sealant as described herein.

1.03 SUBMITTALS

A. See Administrative Requirements for submittal procedures.

B. Contractor shall submit fully coordinated shop drawings for noise control equipment. These submittals shall state the acoustical performance of the products as described below.

C. Isolators – Submit schedule for all vibration isolators indicating the following:
   1. Submit schedule for all vibration isolators indicating the following:
   2. Manufacturer, type, model number, size
   3. Static deflection of each isolation element
   4. Spring constant of each spring-type isolation element
   5. Estimated imposed load on each isolation element
   6. Spring o.d., free operating, and solid heights
   7. Design of supplementary bases
   8. Seismic restraints
   9. Catalog cuts
1.04 QUALITY ASSURANCE

A. The installation of all noise and vibration control systems shall be under the supervision of the manufacturer's representative.

B. All vibration isolation equipment and materials shall be provided by a single manufacturer. The following manufacturers are approved, provided systems comply with the specified design and performance requirements:
1. Mason Industries, Inc. – Hauppauge, New York (Basis of Design)
2. Vibration Mountings and Controls – Bloomingdale, New Jersey

C. Warranty: Refer to Division 1 for warranty requirements.

PART 2 PRODUCTS

2.01 GENERAL

A. All equipment provided for noise control shall be new and manufactured specifically for the purpose intended.

2.02 MATERIALS

A. Foam Rod
1. Foam backer rod shall be flexible closed-cell polyethylene suitable for use as a backing for non-hardening sealant.

B. Non-Hardening Sealant
1. Sealant for electrical penetrations shall be non-hardening polysulphide type, such as Tremco Acoustical Sealant or equal.
2. Permanently flexible, approved firestop putty of minimum density 40 pcf (640 kg/m3) and maximum hardness of 60 durometer (Shore A) may be used in lieu of the sealant on foam rod in perimeter walls that are fire rated for all rooms rated NC-35 and for rooms with slab-to-slab acoustical walls.

C. Packing Material for Penetrations
1. Glass fiber or mineral fiber shall be used as specified herein for packing of penetrations through walls and slabs of rooms rated NC-35, rooms with slab-to-slab acoustical walls, and mechanical/electrical rooms.
2. Glass or mineral fiber; non-combustible; resistant to water, mildew and vermin. USG Thermafiber, 2.5 pcf density, or equivalent product by Roxul, Inc.

2.03 EQUIPMENT

A. All equipment provided for vibration isolation or noise control shall be new and manufactured specifically for the purpose intended.

B. General:
1. All vibration isolators shall have either known un-deflected heights or calibration markings so verification can be made after adjustment that loads are within proper range of the device.
2. All isolators shall operate in the linear portion of their load versus deflection curve.
3. The theoretical vertical natural frequency for each support point, based upon load per isolator and isolator stiffness, shall not differ from the design objectives for the equipment by more than ±10%.

4. All neoprene mountings shall possess Shore hardness of 30 to 60 ±5, or as specified herein, after minimum aging of 20 days or corresponding over-aging.

5. Housed or caged spring isolators are not acceptable.

6. Mounting assemblies for spring isolators shall utilize bare steel springs with the spring diameter not less than 80% of the loaded operating height of the spring. Each spring isolator shall be designed and installed so that the ends of the spring remain parallel during and after the spring installation. All isolators shall operate in the linear portion of their load/deflection curve and have 50% excess capacity without becoming coil bound.

7. All mounting systems exposed to weather and other corrosive environments shall be protected with factory corrosion resistance. All metal parts of mountings (except springs and hardware) shall be hot dip galvanized. Springs shall be cadmium plated and neoprene coated. Nuts and bolts shall be cadmium plated.

C. Isolator Type WP

1. Type WP (Waffle Pads) shall be minimum 5/16” thick neoprene pads ribbed or waffled on both sides. The pads shall be selected for 15% strain. Neoprene shall be bridge-bearing quality with a maximum durometer of 40. Where required to meet the strain criteria, steel load-spreading plates shall be incorporated between the equipment and the neoprene pad.

2. If the isolator is bolted to the structure, a neoprene vibration isolation washer and sleeve (Uniroyal Type 620/660 or as approved) shall be installed under the bolt head between the steel washer and the base plate.

3. (Type WP: Mason Industries Type W or as approved.)

D. Isolator Type MWP

1. Type MWP (Metal and Waffle Sandwich Pads) shall consist of two 5/16” thick ribbed or waffle neoprene pads sandwiching a 16 gauge stainless steel plate. The pad shall be designed for 15% strain. Neoprene shall be bridge bearing quality with a maximum durometer of 40.

2. If the isolator is bolted to the structure, a neoprene vibration isolation washer and sleeve (Uniroyal Type 620/660 or as approved) shall be installed under the bolt head between the steel washer and the base plate.

3. (Type MWP: Mason Industries Type WSW or as approved.)

E. Isolator Type NIS

1. Type NIS isolators shall employ a neoprene element to provide isolation in tension, shear or compression. Neoprene shall be bridge bearing quality with a maximum durometer of 40.

2. (Type NIS: Mason Industries Type RBA or as approved.)

F. Isolator Type DDNM

1. Type DDNM (Double Deflection Neoprene Mounts) shall be laterally stable, double deflecting, molded neoprene isolators. All metal surfaces shall be covered with neoprene. The top and bottom surfaces shall be ribbed, and bolt holes shall be provided in the base. The mounts shall have leveling bolts rigidly secured to the equipment.

2. The strain on the neoprene shall not exceed 15%. Neoprene shall be bridge bearing
quality with a maximum durometer of 40. DDNM mounts shall be selected for a static
deflection of 3/8” unless otherwise specified

3. (Type DDNM: Mason Industries Type ND or as approved.)

G. Isolator Type DDNH

1. Type DDNH (Double Deflection Neoprene Hangers) shall consist of a molded neoprene
element in a steel hanger box. A neoprene sleeve shall be located where the lower
hanger rod passes through the steel box supporting the isolator, such that the hanger rod
cannot contact the steel hanger body. The diameter of the clear hole in the mounting box
shall be at least 3/4” larger than the diameter of the hanger rod and permit the hanger rod
to swing through a 30 degree arc. When installed, the hanger box shall be allowed to
rotate through a full 360 degree arc without encountering any obstructions.

2. Unless otherwise specified, the static deflection of DDNH hangers shall be 0.3” with a
strain not exceeding 15%. Neoprene shall be bridge-bearing quality with a maximum
durometer of 40.

3. (Type DDNH: Mason Industries Type HD or as approved.)

H. Isolator Type SPNM

1. Type SPNM (Spring and Neoprene Mounts) shall be free standing and laterally stable
without any housing. Springs shall be designed so that the ratio of the horizontal to
vertical spring constant is between one and two. The spring diameter shall be not less
than 80% of the compressed height of the spring at rated load. Loaded springs shall
have a minimum additional travel to solid equal to 50% of the specified static deflection.

2. Unless otherwise specified, the minimum static deflection of SPNM isolators for
equipment mounted on grade slabs shall be 1” and the minimum static deflection for
equipment mounted above grade level shall be 2”.

3. Two Type WP isolation pads sandwiching a 16 ga. stainless or galvanized steel separator
plate shall be bonded to the isolator baseplate.

4. Unless otherwise specified, isolators need not be bolted to the floor for indoor
installations. If the base plates are bolted to the structure, a neoprene vibration isolation
washer and sleeve (Uniroyal Type 620/660 or as approved) shall be installed under the
bolt head between the steel washer and the base plate.

5. (Type SPNM: Mason Industries Type SLF or as approved.)

I. Isolator Type SPNH

1. Type SPNH (Spring and Neoprene Hangers) shall consist of a steel spring in series with
a neoprene element. The spring shall have a minimum additional travel to solid equal to
50% of the specified deflection. The neoprene element shall have a static deflection of
not less than 0.3” with a strain not exceeding 15%. Neoprene shall be bridge-bearing
quality with a maximum durometer of 40.

2. Unless otherwise specified, the static deflection of SPNH hangers shall be 2”.

3. Spring diameter and hanger box hole size shall be large enough to permit the hanger rod
to swing through a 30 degree arc. A neoprene sleeve shall be inserted in the steel
hanger box where the lower hanger rod passes through it, such that the hanger rod
cannot contact the steel hanger body. The diameter of the clear hole in the mounting box
shall be at least 3/4” larger than the diameter of the hanger rod. When installed, the
spring element shall not be cocked, and the hanger box shall be allowed to rotate through
a full 360 degree arc without compromising a minimum clearance of 1”.

4. (Type SPNH: Mason Industries Type 30N or as approved.)
J. Neoprene Mounting Sleeves
   1. Neoprene mounting sleeves for hold down applications of equipment with vibration isolators shall be Uniroyal Type 620/660 or as approved.

PART 3 EXECUTION

3.01 INSPECTION
   A. Examine areas and conditions under which vibration control units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Owner or his representative.

3.02 TRANSFORMER ISOLATION
   A. Internally-located, floor-mounted transformers shall be vibration isolated per the schedule below. Exterior, pad-mounted transformers do not require external vibration isolation unless the supporting pad is structurally tied to the building structural system.

   
   Transformer Isolation Requirements

<table>
<thead>
<tr>
<th>Size</th>
<th>Location</th>
<th>Mounting</th>
<th>Isolator Type</th>
<th>Static Deflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 500 VA</td>
<td>any</td>
<td>MWP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>500 VA - 50kVA</td>
<td>all</td>
<td>floor</td>
<td>DDNM or NIS</td>
<td>3/8&quot;</td>
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<tr>
<td></td>
<td>suspended</td>
<td>DDNH</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>≥ 50 kVA on grade</td>
<td>floor</td>
<td>SPNM</td>
<td>1&quot;</td>
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<td>SPNM</td>
<td>1&quot;</td>
</tr>
<tr>
<td>≥ 50 kVA</td>
<td>suspended</td>
<td>above grade</td>
<td>SPNH</td>
<td>1&quot;</td>
</tr>
</tbody>
</table>

   B. All wiring connections to a transformer isolated by Type SPNM or Type SPNH isolators shall be made with a flexible conduit in a slack U-shape.

3.03 MOTORS AND ELECTRICAL EQUIPMENT
   A. All wiring connections to motors and electrical equipment supported on vibration isolators shall be made with flexible conduit installed in a slack U-shape. Flexible conduit and cable shall be capable of and recommended for such curvature.

3.04 SOUND SYSTEM RACKS
   A. All sound and communication racks shall be mounted on Type MWP isolators.

3.05 PENETRATIONS OF WALLS AND SLABS
   A. All conduit and cable penetrations of the following rooms shall be packed and caulked airtight at the following locations (in addition to any fire rating requirements – these take precedence in all situations):
      1. Mechanical Equipment Rooms.
      2. Electrical Equipment Rooms.
      3. All slab penetrations that are not enclosed in a masonry shaft.
      4. All rooms rated NC-35 in section 1.02.

   B. Where a conduit or cable passes through such a wall or slab, the internal diameter of the penetration shall be larger than the external diameter of the conduit passing through it by 2” for conduit 2” and over, and by 1” for conduit under 2”. After all the conduit is installed, Contractor shall check the clearance and correct it if necessary to within 1/4”. The void shall be packed nearly full depth with glass fiber; install foam backer rod on both sides, recessed into the sleeve by 1/2”. Cover the backer rod 1/2” deep with non-hardening, non-aging
C. Alternatively, the void between penetration and conduit shall be filled full depth with GE silicone sealant Type RTV6428 or approved material with equal density and flexibility. For penetrations in fire rated assemblies, use approved non-hardening, non-shrinking fire stop putty in lieu of the sealant and foam rod.

3.06 **ADJUSTING AND CLEANING**

A. Contractor shall work in accordance with best trade practices, shall fabricate and install all items in accordance with manufacturer’s recommendations and Architect’s directions, and shall consult with trades doing adjoining work to provide an installation of first-class quality.

B. Clean each vibration control unit, and verify that each is working freely, and that there is no dirt or debris in immediate vicinity of unit that could possibly short-circuit unit isolation.

**END OF SECTION**
SECTION 26 0553
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL
1.01 SECTION INCLUDES
   A. Electrical identification requirements.
   B. Identification nameplates and labels.
   C. Wire and cable markers.
   D. Underground warning tape.
   E. Warning signs and labels.

1.02 RELATED REQUIREMENTS
   A. Section 09 9113 - Exterior Painting.
   B. Section 09 9123 - Interior Painting.
   C. Section 26 0519 - Conductors and Cable: Color coding for power conductors and cables 600 V and less; vinyl color coding electrical tape.
   D. Section 26 2726 - Wiring Devices - Lutron: Device and wallplate finishes; factory pre-marked wallplates.
   E. Section 27 1000 - Structured Cabling and Equipment for Voice and Data: Identification for communications cabling and devices.

1.03 REFERENCE STANDARDS
   C. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
   D. NFPA 70E - Standard for Electrical Safety in the Workplace; 2015.

1.04 SUBMITTALS
   A. See Section 26 0010 - General Electrical Requirements for submittal procedures.
   B. Samples:
      1. Identification Nameplates: One of each type and color specified.
      2. Warning Signs and Labels: One of each type and legend specified.

1.05 FIELD CONDITIONS
   A. Do not install adhesive products when ambient temperature is lower than recommended by manufacturer.
PART 2 PRODUCTS

2.01 IDENTIFICATION REQUIREMENTS

A. Identification for Equipment:

1. Use identification nameplate to identify each piece of electrical distribution and control equipment and associated sections, compartments, and components.
   a. Switchboards:
      1) Identify ampere rating.
      2) Identify voltage and phase.
      3) Use identification nameplate to identify main overcurrent protective device.
      4) Use identification nameplate to identify load(s) served for each branch device. Identify spares and spaces.
   b. Panelboards:
      1) Designation name from Single Line Diagram.
      2) Identify voltage and phase.
      3) Identify power source and circuit number. Include location when not within sight of equipment. Provide site map as required by AHJ.
      4) Identify main overcurrent protective device. Use identification label for panelboards with a door. For power distribution panelboards without a door, use identification nameplate.
      5) Use typewritten circuit directory to identify load(s) served for panelboards with a door. Identify spares and spaces using pencil.
      6) For power panelboards without a door, use identification nameplate to identify load(s) served for each branch device. Identify spares and spaces.
   c. Transformers:
      1) Designation name from Single Line Diagram.
      2) Identify kVA rating.
      3) Identify voltage and phase for primary and secondary.
      4) Identify power source and circuit number. Include location when not within sight of equipment.
   d. Enclosed Variable Motor Drives (VFD/VSD):
      1) Identify voltage and phase.
      2) Identify power source and circuit number. Include location when not within sight of equipment.
      3) Identify load(s) served. Include location when not within sight of equipment.
   e. Time Switches:
      1) Identify load(s) served and associated circuits controlled. Include location.
   f. Enclosed Contactors:
      1) Identify ampere rating.
      2) Identify voltage and phase.
      3) Identify coil voltage.
      4) Identify load(s) and associated circuits controlled. Include location.
   g. Transfer Switches:
      1) Identify voltage and phase.
      2) Identify power source and circuit number for both normal power source and standby power source. Include location when not within sight of equipment.

2. Emergency System Equipment:

a. Use identification nameplate or voltage marker to identify emergency system equipment in accordance with NFPA 70.
b. Use identification nameplate at each piece of service equipment to identify type and location of on-site emergency power sources.

3. Use identification nameplate to identify disconnect location for equipment with remote disconnecting means.

4. Use identification label or identification nameplate on inside of door at each fused switch to identify required NEMA fuse class and size.

5. Use identification label on inside of door at each motor controller to identify nameplate horsepower, full load amperes, code letter, service factor, voltage, and phase of motor(s) controlled.

6. Use identification label to identify overcurrent protective devices for branch circuits serving fire alarm circuits. Identify with text "FIRE ALARM CIRCUIT".

7. Available Fault Current Documentation: Use identification label to identify the available fault current and date calculations were performed at locations requiring documentation by NFPA 70, including but not limited to the following.
   a. Service equipment.

8. Arc Flash Hazard Warning Labels: Use warning labels to identify arc flash hazards for electrical equipment, such as switchboards, panelboards, industrial control panels, meter socket enclosures, and motor control centers that are likely to require examination, adjustment, servicing, or maintenance while energized.
   a. Legend: Include orange header that reads "WARNING", followed by the word message "Arc Flash and Shock Hazard; Appropriate PPE Required; Do not operate controls or open covers without appropriate personal protection equipment; Failure to comply may result in injury or death; Refer to NFPA 70E for minimum PPE requirements" or approved equivalent.

9. Use warning signs to identify electrical hazards for entrances to all rooms and other guarded locations that contain exposed live parts operating at 600 V nominal or less with the word message "DANGER; Electrical hazard; Authorized personnel only" or approved equivalent.

10. Use warning labels, identification nameplates, or identification labels to identify electrical hazards for equipment where multiple power sources are present with the word message "DANGER; Hazardous voltage; Multiple power sources may be present; Disconnect all electric power including remote disconnects before servicing" or approved equivalent.

B. Identification for Conductors and Cables:
   1. Color Coding for Power Conductors 600 V and Less: Comply with Section 26 0519.
   2. Identification for Communications Conductors and Cables: Comply with Section 27 1005.
   3. Use identification nameplate or identification label to identify color code for ungrounded and grounded power conductors inside door or enclosure at each piece of feeder or branch-circuit distribution equipment.
   4. Use underground warning tape to identify direct buried cables.

C. Identification for Raceways:
   1. Use handwritten text using indelible marker to identify circuits enclosed for accessible conduits at wall penetrations, at floor penetrations, at roof penetrations, and at equipment terminations when source is not within sight.
   2. Use underground warning tape to identify underground raceways.

D. Identification for Boxes:
   1. Use color coded boxes to identify specified systems.
      a. Color-Coded Boxes: Field-painted in accordance with Section 09 9123 and 09 9113 per the same color code used for raceways.
         1) Fire Alarm System: Red.
      b. For exposed boxes in public areas, do not color code.
   2. Use handwritten text using indelible marker to identify circuits enclosed.
a. For exposed boxes in public areas, provide identification on inside face of cover.
b. Label all junction boxes with Panel Designation, Circuit Number, and Voltage

E. Identification for Devices:
1. Identification for Communications Devices: Comply with Section 27 1000.
2. Wiring Device and Wallplate Finishes: Comply with Section 26 2726.
3. Use identification label to identify fire alarm system devices.
   a. For devices concealed above suspended ceilings, provide additional identification on ceiling tile below device location.
4. Use identification label or engraved wallplate to identify serving branch circuit for all receptacles.
   a. For receptacles in public areas, provide identification on inside surface of wallplate.
5. Use identification label to identify load controlled for wall-mounted control devices controlling loads that are not visible from the control location and for multiple wall-mounted control devices installed at one location.

2.02 IDENTIFICATION NAMEPLATES AND LABELS

A. Identification Nameplates:
1. Materials:
   a. Indoor Clean, Dry Locations: Use plastic nameplates.
   b. Outdoor Locations: Use plastic or aluminum nameplates suitable for exterior use.
2. Plastic Nameplates: Two-layer or three-layer laminated acrylic or electrically non-conductive phenolic with beveled edges; minimum thickness of 1/16 inch; engraved text.
   a. Exception: Provide minimum thickness of 1/8 inch when any dimension is greater than 4 inches.
3. Aluminum Nameplates: Anodized; minimum thickness of 1/32 inch; engraved or laser-etched text.
4. Mounting Holes for Mechanical Fasteners: Two, centered on sides for sizes up to 1 inch high; Four, located at corners for larger sizes.

B. Identification Labels:
1. Materials: Use self-adhesive laminated plastic labels; UV, chemical, water, heat, and abrasion resistant.
   a. Use only for indoor locations.
2. Text: Use factory pre-printed or machine-printed text. Do not use handwritten text unless otherwise indicated.

C. Format for Equipment Identification:
1. Minimum Size: 1 inch by 2.5 inches.
2. Legend:
   a. Equipment designation or other approved description.
3. Text: All capitalized unless otherwise indicated.
4. Minimum Text Height:
   a. Equipment Designation: 1/2 inch.
   b. Other Information: 1/4 inch.
5. Color:
   c. Fire Alarm System: Black text on red background.

D. Format for Caution and Warning Messages:
1. Minimum Size: 2 inches by 4 inches.
2. Legend: Include information or instructions indicated or as required for proper and safe operation and maintenance.
3. Text: All capitalized unless otherwise indicated.
4. Minimum Text Height: 1/2 inch.
5. Color: Black text on yellow background unless otherwise indicated.

E. Format for Receptacle Identification:
1. Minimum Size: 3/8 inch by 1.5 inches.
2. Legend: Power source and circuit number or other designation indicated.
3. Text: All capitalized unless otherwise indicated.
5. Color: Black text on clear background.

F. Format for Control Device Identification:
1. Minimum Size: 3/8 inch by 1.5 inches.
2. Legend: Load controlled or other designation indicated.
3. Text: All capitalized unless otherwise indicated.
5. Color: Black text on clear background.

2.03 WIRE AND CABLE MARKERS

A. Markers for Conductors and Cables: Use wrap-around self-adhesive vinyl cloth, wrap-around self-adhesive vinyl self-laminating, heat-shrink sleeve, plastic sleeve, plastic clip-on, or vinyl split sleeve type markers suitable for the conductor or cable to be identified.

B. Markers for Conductor and Cable Bundles: Use plastic marker tags secured by nylon cable ties.

C. Legend: Power source and circuit number or other designation indicated.

D. Text: Use factory pre-printed or machine-printed text, all capitalized unless otherwise indicated.

E. Minimum Text Height: 1/8 inch.

F. Color: Black text on white background unless otherwise indicated.

G. Legend:
1. Power and Lighting Circuits: Branch circuit or feeder number indicated on drawings.
2. Identify feeder and branch circuit conductors using the following colors:
   a. 208/120V system: Phase A - black, phase B - red, phase C - blue, neutral - white, equipment ground - green, switch leg - purple.
   b. 480/277V system: Phase A - brown, phase B - orange, phase C - yellow, neutral - gray, equipment ground - green, switch leg - purple.
   c. Wire #6 AWG and smaller shall be factory color-coded. Wire No. 4 AWG and larger may be factory color-coded, or field coded by taping a minimum 6 inch length of each exposed conductor end with colored tape.
3. Communications Cables: Provide with indelible, permanent identification labels on both ends. Coordinate with owner personnel to verify proper identification schemes. In lieu of owner provided communications, or signal identification schemes, EC to provide labeling per TIA/EIA 606 standards for cabling at each cable end and all termination points.
2.04 UNDERGROUND WARNING TAPE

A. Materials: Use foil-backed detectable type polyethylene tape suitable for direct burial, unless otherwise indicated.

B. Foil-backed Detectable Type Tape: 3 inches wide, with minimum thickness of 5 mil, unless otherwise required for proper detection.

C. Legend: Type of service, continuously repeated over full length of tape.

D. Color:
   1. Tape for Buried Power Lines: Black text on red background.

2.05 WARNING SIGNS AND LABELS

A. Comply with ANSI Z535.2 or ANSI Z535.4 as applicable.

B. Warning Signs:
   1. Minimum Size: 7 by 10 inches unless otherwise indicated.

C. Warning Labels:
   1. Materials: Use factory pre-printed or machine-printed self-adhesive polyester or self-adhesive vinyl labels; UV, chemical, water, heat, and abrasion resistant; produced using materials recognized to UL 969.
   3. Minimum Size: 2 by 4 inches unless otherwise indicated.

PART 3 EXECUTION

3.01 PREPARATION

A. Clean surfaces to receive adhesive products according to manufacturer's instructions.

B. Degrease and clean surfaces to receive nameplates and labels.

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install identification products to be plainly visible for examination, adjustment, servicing, and maintenance. Unless otherwise indicated, locate products as follows:
   3. Free-Standing Equipment: Enclosure front; also enclosure rear for equipment with rear access.
   4. Elevated Equipment: Legible from the floor or working platform.
   5. Branch Devices: Adjacent to device.
   6. Interior Components: Legible from the point of access.
   7. Conduits: Legible from the floor.
   8. Boxes: Outside face of cover.
   9. Conductors and Cables: Legible from the point of access.
  10. Devices: Outside face of cover.
C. Install identification products centered, level, and parallel with lines of item being identified.

D. Secure nameplates to exterior surfaces of enclosures using stainless steel screws and to interior surfaces using self-adhesive backing or epoxy cement.

E. Install self-adhesive labels and markers to achieve maximum adhesion, with no bubbles or wrinkles and edges properly sealed.

F. Install underground warning tape above buried lines with one tape per trench at 3 inches below finished grade.

G. Mark all handwritten text, where permitted, to be neat and legible.

3.03 FIELD QUALITY CONTROL

A. Replace self-adhesive labels and markers that exhibit bubbles, wrinkles, curling or other signs of improper adhesion.

END OF SECTION
IDENTIFICATION FOR ELECTRICAL SYSTEMS
PART 1 GENERAL

1.01 SECTION INCLUDES

A. Electrical connections to equipment.

1.02 REFERENCE STANDARDS

A. NEMA WD 1 - General Color Requirements for Wiring Devices; 1999 (R 2010).
B. NEMA WD 6 - Wiring Devices - Dimensional Specifications; 2012.
C. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Obtain and review shop drawings, product data, manufacturer's wiring diagrams, and manufacturer's instructions for equipment furnished under other sections.
   2. Determine connection locations and requirements.

B. Sequencing:
   1. Install rough-in of electrical connections before installation of equipment is required.
   2. Make electrical connections before required start-up of equipment.

1.04 SUBMITTALS

A. See Section 26 0010 - General Electrical Requirements for submittal procedures.

1.05 QUALITY ASSURANCE

A. Conform to requirements of NFPA 70.
B. Products: Listed, classified, and labeled as suitable for the purpose intended.

PART 2 PRODUCTS

2.01 MATERIALS

A. Cords and Caps: NEMA WD 6; match receptacle configuration at outlet provided for equipment.
   1. Colors: Conform to NEMA WD 1.
   2. Cord Construction: NFPA 70, Type SO, multiconductor flexible cord with identified equipment grounding conductor, suitable for use in damp locations.
   3. Size: Suitable for connected load of equipment, length of cord, and rating of branch circuit overcurrent protection.

B. Disconnect Switches: As specified in Section 26 2818.

C. Wiring Devices: As specified in Section 26 2726.

D. Flexible Conduit: As specified in Section 26 0533.

E. Wire and Cable: As specified in Section 26 0519.

F. Boxes: As specified in Section 26 0534.
G. Motor Controllers: As specified in Section 26 2913.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that equipment is ready for electrical connection, wiring, and energization.

3.02 EQUIPMENT CONNECTIONS

A. Furnish and install all wiring except temperature control wiring, equipment control wiring which does not conduct full load motor current, and interlock wiring, unless indicated otherwise. Furnish and install all power wiring complete from power source to motor or equipment junction box, including power wiring through starters.

B. Unless otherwise indicated, all hvac and plumbing equipment motors and controls shall be furnished, set in place, and wired in accordance with the following schedules:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Furnished By</th>
<th>Installed By</th>
<th>Power Wired By</th>
<th>Control Wired By</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment motors</td>
<td>MC</td>
<td>MC</td>
<td>EC</td>
<td>-</td>
</tr>
<tr>
<td>Magnetic motor starters, manual or auto control w/ or w/o hand-off-auto</td>
<td>EC</td>
<td>EC</td>
<td>EC</td>
<td>MC</td>
</tr>
<tr>
<td>Magnetic motor starters supplied as part of factory wired equipment</td>
<td>MC</td>
<td>MC</td>
<td>EC</td>
<td>MC</td>
</tr>
<tr>
<td>Combination magnetic motor starter disconnects</td>
<td>EC</td>
<td>EC</td>
<td>EC</td>
<td>MC</td>
</tr>
<tr>
<td>Disconnect switches and thermal overload switches</td>
<td>EC</td>
<td>EC</td>
<td>EC</td>
<td>-</td>
</tr>
<tr>
<td>Pushbuttons and pilot lights:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Full load motor amps</td>
<td>MC</td>
<td>EC</td>
<td>EC</td>
<td>EC</td>
</tr>
<tr>
<td>b. Non-full load motor amps</td>
<td>MC</td>
<td>MC</td>
<td>-</td>
<td>MC</td>
</tr>
<tr>
<td>Temperature control relays and transformers</td>
<td>MC</td>
<td>MC</td>
<td>EC</td>
<td>MC</td>
</tr>
<tr>
<td>Thermostats and time clocks:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Full load motor amps</td>
<td>MC</td>
<td>EC</td>
<td>EC</td>
<td>EC</td>
</tr>
<tr>
<td>b. Non-full load motor amps</td>
<td>MC</td>
<td>MC</td>
<td>-</td>
<td>MC</td>
</tr>
<tr>
<td>Temperature control panels and time clocks mounted within panels</td>
<td>MC</td>
<td>MC</td>
<td>EC</td>
<td>MC</td>
</tr>
</tbody>
</table>
Motorized valves, damper motors and remote bulb thermostats

Solenoid valves, PE switches, EP switches, etc.

Smoke detectors and relays for fan shutdown:
- a. Bldg w/ fire alarm system
- b. Bldg w/o fire alarm system

Boiler and/or burner controls

C. For equipment furnished under MC, EC to install all starters and disconnects not factory mounted on equipment. The Mechanical Contractor shall provide and be responsible for the overload "heaters" in all starters furnished under Divisions 22 and 23.

D. Control relay and control transformers shall be furnished under the mechanical contract except where furnishing such items is specifically required under the electrical specifications and/or drawings.

E. EC shall provide power to all temperature control panels. Location and quantity of control panels shall be determined by control contractor.

F. Provide field-installed disconnect switch when not in direct sight of Panelboard, Loadcenter, or Motor Controller.

3.03 ELECTRICAL CONNECTIONS

A. Make electrical connections in accordance with equipment manufacturer's instructions.

B. Make conduit connections to equipment using flexible conduit. Use liquidtight flexible conduit with watertight connectors in damp or wet locations.

C. Connect heat producing equipment using wire and cable with insulation suitable for temperatures encountered.

D. Provide receptacle outlet to accommodate connection with attachment plug.

E. Provide cord and cap where field-supplied attachment plug is required.

F. Install suitable strain-relief clamps and fittings for cord connections at outlet boxes and equipment connection boxes.

G. Install disconnect switches, controllers, control stations, and control devices to complete equipment wiring requirements.

H. Install terminal block jumpers to complete equipment wiring requirements.

I. Install interconnecting conduit and wiring between devices and equipment to complete equipment wiring requirements.
J. Provide hardwired electrical connections using flexible conduit.

END OF SECTION
1.04 LIGHTING CONTROL APPLICATIONS

A. SUBMITTALS
   1. Submittals Package: Submit the shop drawings, and the product data specified below at the same time as a package.
   2. Shop Drawings (For Sensor Systems):
      a. Composite wiring and/or schematic diagram of each control circuit as proposed to be installed (standard diagrams will not be accepted).
      b. Scale drawing for each area showing exact location of each sensor, switching module, and on-off-auto switch.
   3. Product Data: Catalog sheets, specifications and installation instructions.
   4. Include data for each device which:
      a. Indicates where sensor is proposed to be installed per manufacturers guidelines.
      b. Prove that the sensor is suitable for the proposed application.

B. QUALITY ASSURANCE

1.05 WARRANTY

A. Provide a five year complete manufacturer's warranty on all products to be free of manufacturers' defects.

1.06 MAINTENANCE

A. Spare Parts:
   1. Provide 2 of each product to be used for maintenance.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Acceptable Manufacturer:
   1. Basis of design product: Watt Stopper Digital Lighting Management (DLM) or subject to compliance and prior approval with specified requirements of this section, one of the following:
      a. Acceptable equal
   2. Substitutions:
      a. All proposed substitutions (clearly delineated as such) must be submitted in writing for approval by the design professional a minimum of 10 working days prior to the bid date and must be made available to all bidders. Proposed substitutes must be accompanied by a review of the specification noting compliance on a line-by-line basis.
      b. By using pre-approved substitutions, the contractor accepts responsibility and associated costs for all required modifications to circuitry, devices, and wiring. The contractor shall provide complete engineered shop drawings (including power wiring) with deviations for the original design highlighted in an alternate color to the engineer for review and approval prior to rough-in.

2.02 DIGITAL WALL OR CEILING MOUNTED OCCUPANCY SENSOR SYSTEM

A. Wall or ceiling mounted (to suit installation) dual technology digital (passive infrared and ultrasonic) occupancy sensor. Furnish the Company's system which accommodates the square footage coverage requirements for each area controlled, utilizing Room Controller modules and accessories which suits the lighting and electrical system parameters.
B. Digital Occupancy Sensors shall provide graphic LCD display for digital calibration and electronic documentation. Features include the following:

1. Digital calibration and LCD entry for the following variables:
   a. Sensitivity 0-100% in 10% increments
   b. Time Delay - Fixed (1-30 minutes in 1 minute increments), and automatic
   c. Test mode - Five second time delay
   d. PIR, Ultrasonic or Dual Technology activation and/or re-activation.
   e. Walk-through mode
   f. Load parameters including auto/manual ON, blink warning, and daylight enable/disable.

2. RJ-45 digital connections for DLM local network.
3. Two-way infrared communications port to allow remote programming through hand held commissioning tool.
4. Self contained push buttons for programming and control of room devices.
5. Device Status LED's including:
   a. PIR Detection
   b. Configuration mode
   c. Load binding

6. Assignment of occupancy sensor to a specific load within the room without wiring or special tools.

C. Units will provide for digital calibration and commissioning and will not have any dip switches or potentiometers for field settings

D. Multiple occupancy sensors may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration will be required

E. Watt Stopper product number: LMDX-100 wall and LMDC-100 ceiling

2.03 DIGITAL WALL SWITCHES

A. Low voltage (RJ-45) wall switch, decorator opening. Wall switches will include the following features:

1. Two way infrared communications port for use with personal and configuration remote controls.
2. Control button with LED status indicator
3. Dimming switches shall include seven LED's to indicate load levels.
4. Hidden configuration button for access to Push n'Learn mode.

B. Switches shall have two RJ-45 ports to allow connection to any other digital room device.

C. Multiple digital wall switches may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration will be required to achieve multi-way switching

D. Watt Stopper product number: LMSW-100 SERIES or LMDM-100 SERIES.

2.04 ROOM CONTROLLERS

A. Room Controllers automatically bind the room loads to the connected devices in the space without any tools or configuration requirements. Room Controllers shall be provided to match the room lighting load and control requirements and sequences. The controllers will be simple to install and will not have screw type connections, dip switches, potentiometers or require special mounting or configuration. The control units will include the following features:
1. Automatic room configuration to the most energy efficient sequence of operation based upon the devices in the room.
2. One, two or three relay configuration
3. Device Status LED's to indicate:
   a. Data transmission
   b. Device has power
   c. Status for each load
   d. Configuration status
4. Quick installation features including:
   a. Standard junction box mounting (inside or outside)
   b. Quick low voltage connections using standard RJ-45 patch cable
5. Plenum rated
6. Manual override and LED indication for each load
7. Universal voltage (120/230/277 VAC, 50-60 Hz)
8. Zero cross circuitry for each load.
9. Three RJ-45 DLM local network ports
10. Watt Stopper product numbers: LMRC-100 SERIES

B. 0-10 Volt enhanced Room Controllers shall include all the features of the Room Controller plus the following enhancements:
1. One, two or three relay configuration
2. Efficient 250 ma switching power supply
3. Four RJ-45 DLM local network ports.
4. One zero to 10 volt analog output per relay for control of dimmable ballasts.
5. Optional BACnet MS/TP communications port.
6. Current monitoring
7. Watt Stopper product numbers: LMRC-210 SERIES.

2.05 DIGITAL PHOTOSENSORS

A. Provide automatic daylight harvesting capabilities to the Room Controllers. The photo sensor / room controller configuration automatically configures the daylighting set points for ON/OFF. Using the automatic configuration replacing a photo sensor or room controller can be done without any special tools, programming or configuration. Photosensors include the following features:
1. The digital photosensor shall utilize an internal photodiode that measures light in a 100 degree angle cutting the unwanted light from bright sources outside of this cone
2. The digital photosensor shall be capable of turning lighting on and off or Raise / Lower depending on the binding to the Room Controller. Sensor range shall be from 1 - 1400fc.
3. For ON/OFF daylight harvesting the controller provides a “hold on while occupied” feature that prohibits high levels from turning OFF the controlled lights as long as the space remains occupied.
4. The sensor has a threaded nipple that mounts on a ceiling tile and for more challenging applications such as a side wall or hard rock ceiling the nipple pops off and the unit can be screwed down
5. 0-10V output for control of dimmable ballasts.


C. Watt Stopper Product Numbers: LMLS-105 non-dimming.
2.06 ROOM NETWORK

A. The DLM local network is a free topology lighting control network and protocol designed to control a small area of a building. Digital room devices connect to the network using RJ-45 patch cords which provide both data and power to room devices. Features of the DLM local network include
   1. Automatic configuration and binding of sensors, switches and lighting loads to the most energy efficient sequence of operation based upon the device attached.
   2. Simple replacement of any device in the network with a standard off the shelf unit without requiring commissioning, configuration or setup.
   3. Push and Learn configuration that can change the automatic binding process and load parameters by using only the digital devices in the room.
   4. Two way infrared communications that allow load parameters, sensor configuration and binding operations to be configured through a hand held configuration tool up to 30 feet from any device.

2.07 EMERGENCY LIGHTING

A. Emergency Lighting Control Unit - A UL 924 listed device that monitors a switched circuit providing normal lighting to an area. The unit provides normal ON/OFF control of emergency lighting along with the normal lighting. Upon normal power failure the emergency lighting circuit will close, forcing the emergency lighting ON until normal power is restored. Features include
   1. 120 - 277 volts, 50/60 Hz., 20 amp ballast rating
   2. Push to test button

PART 3 – EXECUTION

3.01 INSTALLATION

A. When using wire other than RJ-45 connections provide detailed point to point wiring diagrams for every termination. Provide wire specifications and wire colors to simplify contactor termination requirements

B. Install the work of this Section in accordance with manufacturer’s printed instructions unless otherwise indicated.

C. Provide occupancy sensor(s) in rooms shown on the drawings. Provide quantity of occupancy sensors in these rooms as required for complete coverage of the entire room.

D. Calibrate all sensor time delays and sensitivity to guarantee proper coverage of occupants and energy savings.
   1. Adjust time delay so that controlled area remains lighted for 5 minutes after occupant leaves area.

E. Provide written or computer generated documentation on the commissioning of the system including room by room description including:
   1. Sensor parameters, time delays, sensitivities, daylighting set points.
   2. Sequence of operation, manual ON, Auto OFF. Etc.
   3. Load Parameters - blink warning, etc.

F. Re-commissioning - After 30 days from occupancy re-calibrate all sensors time delays and sensitivities to meet the Owner's Project Requirements. Provide a detailed report to the Architect / Owner of re-commissioning activity

G. Provide (2) hand held remotes for room configuration programming to owner.
3.02 FACTORY COMMISSIONING.

A. Upon completion of the installation, the system shall be commissioned by the manufacturer's factory authorized representative who will verify a complete fully functional system.

B. The electrical contractor shall provide both the manufacturer and the electrical engineer with ten working days written notice of the system startup and adjustment date.

C. Upon completion of the system commissioning the factory authorized technician shall provide the proper training to the owner's personnel on the adjustment and maintenance of the system.

END OF SECTION
SECTION 26 2200
LOW-VOLTAGE (DRY-TYPE) TRANSFORMERS

PART 1 GENERAL
1.01 SECTION INCLUDES
   A. General purpose transformers.

1.02 RELATED REQUIREMENTS
   A. Section 26 0526 - Grounding and Bonding.
   B. Section 26 0533 - Conduit for Electrical Systems: Flexible conduit connections.
   C. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.

1.03 REFERENCE STANDARDS
   A. IEEE C57.94 - IEEE Recommended Practice for Installation, Application, Operation, and Maintenance of Dry-Type General Purpose Distribution and Power Transformers; 1982 (R2006).
   B. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
   C. NECA 409 - Standard for Installing and Maintaining Dry-Type Transformers; 2009.
   D. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
   E. UL 1561 - Standard for Dry-Type General Purpose and Power Transformers; Current Edition, Including All Revisions.

1.04 SUBMITTALS
   A. Product Data: Include voltage, kVA, impedance, tap configurations, insulation system class and rated temperature rise, efficiency, sound level, enclosure ratings, outline and support point dimensions, weight, required clearances, service condition requirements, and installed features.
   B. Shop Drawings: Provide dimensioned plan and elevation views of transformers and adjacent equipment with all required clearances indicated.
   C. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
   D. Test Reports: Indicate loss data, efficiency at 25, 50, 75 and 100 percent rated load, and sound level.
   E. Project Record Documents: Record actual locations of transformers.

1.05 DELIVERY, STORAGE, AND HANDLING
   A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
   B. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to transformer internal components, enclosure, and finish.
PART 2 PRODUCTS

2.01 MANUFACTURERS


B. Schneider Electric; Square D Products: www.schneider-electric.us/#sle.


D. Source Limitations: Furnish transformers produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

2.02 TRANSFORMERS - GENERAL REQUIREMENTS

A. Description: Factory-assembled, dry type transformers for 60 Hz operation designed and manufactured in accordance with NEMA ST 20 and listed, classified, and labeled as suitable for the purpose intended.

B. Unless noted otherwise, transformer ratings indicated are for continuous loading according to IEEE C57.96 under the following service conditions:
   1. Ambient Temperature:
      a. Greater than 10 kVA: Not exceeding 104 degrees F.
      b. Less than 10 kVA: Not exceeding 77 degrees F.
   2. Altitude: Less than the State in which the Project is located feet.

C. Core: High grade, non-aging silicon steel with high magnetic permeability and low hysteresis and eddy current losses. Keep magnetic flux densities substantially below saturation point, even at 10 percent primary overvoltage. Tightly clamp core laminations to prevent plate movement and maintain consistent pressure throughout core length.

D. Impregnate core and coil assembly with non-hydroscopic thermo-setting varnish to effectively seal out moisture and other contaminants.

E. Basic Impulse Level: 10 kV.

F. Ground core and coil assembly to enclosure by means of a visible flexible copper grounding strap.

G. Isolate core and coil from enclosure using vibration-absorbing mounts.

H. Nameplate: Include transformer connection data, ratings, wiring diagrams, and overload capacity based on rated winding temperature rise.

2.03 GENERAL PURPOSE TRANSFORMERS

A. Description: Self-cooled, two winding transformers listed and labeled as complying with UL 506 or UL 1561; ratings as indicated on the drawings.

B. Primary Voltage: 480 volts delta, 3 phase.

C. Secondary Voltage: 208Y/120 volts, 3 phase.

D. Insulation System and Allowable Average Winding Temperature Rise:
   1. Less than 15 kVA: Class 180 degrees C insulation system with 115 degrees C average winding temperature rise.
   2. 15 kVA and Larger: Class 220 degrees C insulation system with 150 degrees C average winding temperature rise.
E. Coil Conductors: Continuous aluminum windings with terminations brazed or welded.

F. Winding Taps:
   1. Less than 3 kVA: None.
   2. 3 kVA through 15 kVA: Two 5 percent full capacity primary taps below rated voltage.
   3. 15 kVA through 300 kVA: Two 2.5 percent full capacity primary taps above and four 2.5 percent full capacity primary taps below rated voltage.

G. Sound Levels: Low sound levels at least 3 db less than NEMA ST 20 standard sound levels.

H. Mounting Provisions:
   1. Less than 15 kVA: Suitable for wall mounting.
   2. 15 kVA through 75 kVA: Suitable for floor mounting.
   3. Larger than 75 kVA: Suitable for floor mounting.

I. Transformer Enclosure: Comply with NEMA ST 20.
   1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
      a. Indoor clean, dry locations: Type 2.
      b. Outdoor locations: Type 3R.
   2. Construction: Steel.
      a. Less than 15 kVA: Totally enclosed, non-ventilated.
      b. 15 kVA and Larger: Ventilated.
   3. Finish: Manufacturer's standard grey, suitable for outdoor installations.
   4. Provide lifting eyes or brackets.

J. Accessories:
   1. Mounting Brackets: Provide manufacturer's standard brackets.
   2. Weathershield Kits: Provide for ventilated transformers installed outdoors to provide a listed NEMA 250, type 3R assembly.
   3. Lug Kits: Sized as required for termination of conductors as indicated on the drawings.

PART 3 EXECUTION

3.01 EXAMINATION

   A. Verify that field measurements are as indicated.
   B. Verify that suitable support frames and anchors are installed where required and that mounting surfaces are ready to receive transformers.
   C. Perform pre-installation tests and inspections on transformers per manufacturer's instructions and as specified in NECA 409. Correct deficiencies prior to installation.
   D. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

   A. Perform pre-installation tests and inspections on transformers per manufacturer's instructions and as specified in NECA 409. Correct deficiencies prior to installation.
   B. Perform work in accordance with NECA 1 (general workmanship).
   C. Install products in accordance with manufacturer's instructions.
   D. Install transformers in accordance with NECA 409 and IEEE C57.94.
E. Use flexible conduit, under the provisions of Section 26 0533, 2 feet minimum length, for connections to transformer case. Make conduit connections to side panel of enclosure.

F. Arrange equipment to provide minimum clearances as specified on transformer nameplate and in accordance with manufacturer's instructions and NFPA 70.

G. Install transformers plumb and level.

H. Transformer Support:
   1. Provide required support and attachment in accordance with Section 26 0529, where not furnished by transformer manufacturer.
   2. Unless otherwise indicated, mount floor-mounted transformers on properly sized 3 inch high concrete pad constructed in accordance with Section 03 3000.

I. Provide grounding and bonding in accordance with Section 26 0526.

J. Remove shipping braces and adjust bolts that attach the core and coil mounting bracket to the enclosure according to manufacturer's recommendations in order to reduce audible noise transmission.

K. Where not factory-installed, install lugs sized as required for termination of conductors as indicated.

L. Where furnished as a separate accessory, install transformer weathershield per manufacturer's instructions.

M. Identify transformers in accordance with Section 26 0553.

3.03 ADJUSTING

A. Measure primary and secondary voltages and make appropriate tap adjustments.

B. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

3.04 CLEANING

A. Clean dirt and debris from transformer components according to manufacturer's instructions.

B. Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION
PART 1 GENERAL

1.01 SECTION INCLUDES

A. Power distribution panelboards.
B. Lighting and appliance panelboards.
C. Overcurrent protective devices for panelboards.

1.02 REFERENCE STANDARDS

A. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
B. NECA 407 - Standard for Installing and Maintaining Panelboards; 2009.
C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2014.
D. NEMA PB 1 - Panelboards; 2011.
E. NEMA PB 1.1 - General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less; 2013.
F. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
G. UL 67 - Panelboards; Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
   2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
   3. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted panelboards where indicated.
   4. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
   5. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.04 SUBMITTALS

A. See Section 26 0010 - General Electrical Requirements for submittal procedures.
B. Product Data: Provide manufacturer's standard catalog pages and data sheets for panelboards, enclosures, overcurrent protective devices, and other installed components and accessories.
   1. Include characteristic trip curves for each type and rating of overcurrent protective device upon request.
C. Shop Drawings: Indicate outline and support point dimensions, voltage, main bus ampacity, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.

D. Source Quality Control Test Reports: Include reports for tests designated in NEMA PB 1 as routine tests.

E. Field Quality Control Test Reports.

F. Project Record Documents: Record actual installed locations of panelboards and actual installed circuiting arrangements.

G. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. Panelboard Keys: Two of each different key.

1.05 QUALITY ASSURANCE

A. Conform to requirements of NFPA 70.

B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store panelboards in accordance with manufacturer's instructions and NECA 407.

B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

C. Handle carefully in accordance with manufacturer's written instructions to avoid damage to panelboard internal components, enclosure, and finish.

PART 2 PRODUCTS

2.01 MANUFACTURERS


D. Square D: www.schneider-electric.com

E. Source Limitations: Furnish panelboards and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

2.02 PANELBOARDS - GENERAL REQUIREMENTS

A. Provide products listed, classified, and labeled as suitable for the purpose intended.

B. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
   1. Altitude: Less than 6,600 feet.
   2. Ambient Temperature:
      a. Panelboards Containing Circuit Breakers: Between 23 degrees F and 104 degrees F.

C. Short Circuit Current Rating:
1. Provide panelboards with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings.

D. Mains: Configure for top or bottom incoming feed as required for the installation.

E. Branch Overcurrent Protective Devices: Replaceable without disturbing adjacent devices.

F. Bussing: Sized in accordance with UL 67 temperature rise requirements.
   1. Provide fully rated neutral bus unless otherwise indicated, with a suitable lug for each feeder or branch circuit requiring a neutral connection.
   2. Provide solidly bonded equipment ground bus in each panelboard, with a suitable lug for each feeder and branch circuit equipment grounding conductor.

G. Conductor Terminations: Suitable for use with the conductors to be installed.

H. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
   1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
      a. Indoor Clean, Dry Locations: Type 1.
      b. Outdoor Locations: Type 3R.
   2. Boxes: Galvanized steel unless otherwise indicated.
      a. Provide wiring gutters sized to accommodate the conductors to be installed.
      b. Provide painted steel boxes for surface-mounted panelboards where indicated, finish to match fronts.
   3. Fronts:
      a. Fronts for Surface-Mounted Enclosures: Same dimensions as boxes.
      b. Fronts for Flush-Mounted Enclosures: Overlap boxes on all sides to conceal rough opening.
      c. Finish for Painted Steel Fronts: Manufacturer's standard grey unless otherwise indicated.
   4. Lockable Doors: All locks keyed alike unless otherwise indicated.

I. Future Provisions: Prepare all unused spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.

J. Surge Protective Devices: Where factory-installed, internally mounted surge protective devices are provided in accordance with Section 26 4300, list and label panelboards as a complete assembly including surge protective device.

K. Load centers are not acceptable.

2.03 POWER DISTRIBUTION PANELBOARDS

A. Description: Panelboards complying with NEMA PB 1, power and feeder distribution type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.

B. Conductor Terminations:
   1. Main and Neutral Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
   2. Main and Neutral Lug Type: Mechanical.

C. Bussing:
   1. Phase and Neutral Bus Material: Aluminum or copper.
   2. Ground Bus Material: Aluminum or copper.
D.  Circuit Breakers:
   1.  Provide bolt-on type.
   2.  Provide thermal magnetic circuit breakers unless otherwise indicated.
   3.  Molded Case Circuit Breakers with integral thermal and instantaneous magnetic trip in each pole; UL listed. For air conditioning equipment branch circuits provide circuit breakers UL listed as Type HACR.

E.  Enclosures:
   1.  Provide surface-mounted or flush-mounted enclosures as indicated.
   2.  Fronts: Provide lockable hinged door with concealed hinges for access to overcurrent protective device handles without exposing live parts.
   3.  Provide clear plastic circuit directory holder mounted on inside of door.

2.04 LIGHTING AND APPLIANCE PANELBOARDS

A.  Description: Panelboards complying with NEMA PB 1, lighting and appliance branch circuit type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.

B.  Conductor Terminations:
   1.  Main and Neutral Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
   2.  Main and Neutral Lug Type: Mechanical.

C.  Bussing:
   1.  Phase and Neutral Bus Material: Aluminum or copper.
   2.  Ground Bus Material: Aluminum or copper.

D.  Circuit Breakers: Thermal magnetic trip circuit breakers, bolt-on type, with common trip handle for all poles; UL listed.
   1.  Type SWD for lighting circuits.
   2.  Type HACR for air conditioning equipment circuits.
   3.  Class A ground fault interrupter circuit breakers where scheduled.

E.  Enclosures:
   1.  Provide surface-mounted or flush-mounted enclosures as indicated.
   2.  Fronts: Provide lockable hinged door with concealed hinges for access to overcurrent protective device handles without exposing live parts.
   3.  Provide clear plastic circuit directory holder mounted on inside of door.

2.05 OVERCURRENT PROTECTIVE DEVICES

A.  Molded Case Circuit Breakers:
   1.  Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers listed and labeled as complying with UL 489, and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.
   2.  Interrupting Capacity:
      a.  Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated on drawings.
      b.  Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
   3.  Conductor Terminations:
      a.  Provide mechanical lugs unless otherwise indicated.
b. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.

4. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.

5. Multi-Pole Circuit Breakers: Furnish with common trip for all poles.

6. Provide the following circuit breaker types where indicated:
   a. Ground Fault Circuit Interrupter (GFCI) Circuit Breakers: Listed as complying with UL 943, class A for protection of personnel.
   b. Ground Fault Equipment Protection Circuit Breakers: Designed to trip at 30 mA for protection of equipment.

7. Do not use tandem circuit breakers.

8. Do not use handle ties in lieu of multi-pole circuit breakers.

9. Provide multi-pole circuit breakers for multi-wire branch circuits as required by NFPA 70.

10. Provide the following features and accessories where indicated or where required to complete installation:
    a. Shunt Trip: Provide coil voltage as required for connection to indicated trip actuator.

**PART 3 EXECUTION**

**3.01 INSTALLATION**

A. Perform work in accordance with NECA 1 (general workmanship).

B. Install products in accordance with manufacturer's instructions.

C. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.

D. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.

E. Provide required support and attachment in accordance with Section 26 0529.

F. Install flush-mounted panelboards so that trims fit completely flush to wall with no gaps and rough opening completely covered.

G. Mount panelboards such that the highest position of any operating handle for circuit breakers or switches does not exceed 79 inches above the floor or working platform.

H. Provide minimum of six spare 1 inch trade size conduits out of each flush-mounted panelboard stubbed into accessible space above ceiling and below floor.

I. Provide grounding and bonding in accordance with Section 26 0526.
   1. Terminate branch circuit equipment grounding conductors on solidly bonded equipment ground bus only. Do not terminate on isolated/insulated ground bus.
   2. Terminate branch circuit isolated grounding conductors on isolated/insulated ground bus only. Do not terminate on solidly bonded equipment ground bus.

J. Install all field-installed branch devices, components, and accessories.

K. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.

L. Multi-Wire Branch Circuits: Group grounded and ungrounded conductors together in the panelboard as required by NFPA 70.

M. Install panelboards in accordance with NEMA PB 1.1 and NECA 1.
N. Install panelboards plumb. Install recessed panelboards flush with wall finishes.

O. Provide filler plates to cover unused spaces in panelboards.

P. Provide circuit breaker lock-on devices to prevent unauthorized personnel from de-energizing essential loads where indicated. Also provide for the following:
   1. Fire detection and alarm circuits.
   2. Communications equipment circuits.
   3. Intrusion detection and access control system circuits.
   4. Video surveillance system circuits.

Q. Provide computer-generated circuit directory for each lighting and appliance panelboard and each power distribution panelboard provided with a door, clearly and specifically indicating the loads served. Identify spares and spaces.
   1. Description included on electrical panel schedules are for design purposes only. Description printed on final panel schedules must have a sufficient degree of detail that allows each circuit to be distinguished from all others, as approved by the Authority Holding Jurisdiction.

R. Provide identification nameplate for each panelboard in accordance with Section 26 0553.

S. Provide arc flash warning labels in accordance with NFPA 70.

T. Provide floor markings to clearly indicate required working clearances where indicated or where required by the authority having jurisdiction.

3.02 FIELD QUALITY CONTROL

A. Provide all test results to Engineer in Substantial Completion Submittals, via Architect, prior to scheduling Substantial Completion observations. Test results shall be tabulated to show name of tested device, measured value, expected values, acceptable standard deviation, and test conditions, as well as any miscellaneous variables that may be applicable to test being performed.

B. Test GFCI circuit breakers to verify proper operation.

C. Test shunt trips to verify proper operation.

D. Correct deficiencies and replace damaged or defective panelboards or associated components.

3.03 ADJUSTING

A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

B. Adjust alignment of panelboard fronts.

C. Load Balancing: For each panelboard, rearrange circuits such that the difference between each measured steady state phase load does not exceed 20 percent and adjust circuit directories accordingly. Maintain proper phasing for multi-wire branch circuits.

END OF SECTION
SECTION 26 2726
WIRING DEVICES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Wall switches.
B. Wall dimmers.
C. Receptacles.
D. Wall plates.
E. Floor box service fittings.

1.02 REFERENCE STANDARDS

B. FS W-S-896 - Switches, Toggle (Toggle and Lock), Flush-mounted (General Specification); Federal Specification; Revision F, 1999.
C. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
D. NECA 130 - Standard for Installing and Maintaining Wiring Devices; 2010.
E. NEMA WD 1 - General Color Requirements for Wiring Devices; 1999 (R 2010).
F. NEMA WD 6 - Wiring Devices - Dimensional Specifications; 2012.
G. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the placement of outlet boxes with millwork, furniture, equipment, etc. installed under other sections or by others.
   2. Coordinate wiring device ratings and configurations with the electrical requirements of actual equipment to be installed.
   3. Coordinate the placement of outlet boxes for wall switches with actual installed door swings.
   4. Coordinate the installation and preparation of uneven surfaces, such as split face block, to provide suitable surface for installation of wiring devices.
   5. Coordinate the core drilling of holes for poke-through assemblies with the work covered under other sections.
   6. Notify Architect of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

1.04 SUBMITTALS

A. See Section 26 0010 - General Electrical Requirements for submittal procedures.
B. Product Data: Provide manufacturer's catalog information showing dimensions, colors, and configurations.
C. Field Quality Control Test Reports.
PART 2 PRODUCTS

2.01 MANUFACTURERS

2.02 WIRING DEVICE APPLICATIONS

A. Provide wiring devices suitable for intended use and with ratings adequate for load served.

B. For single receptacles installed on an individual branch circuit, provide receptacle with ampere rating not less than that of the branch circuit.

C. Provide weather resistant GFCI receptacles with specified weatherproof covers for receptacles installed outdoors or in damp or wet locations.

D. Provide GFCI protection for receptacles installed within 6 feet of sinks.

E. Provide GFCI protection for receptacles installed in kitchens.

F. Provide GFCI protection for receptacles serving electric drinking fountains.

G. Unless noted otherwise, do not use combination switch/receptacle devices.

H. For flush floor service fittings, use tile rings for installations in tile floors.

I. For flush floor service fittings, use carpet flanges for installations in carpeted floors.

2.03 WIRING DEVICE FINISHES

A. Wiring Devices, Unless Otherwise Indicated: Gray with stainless steel wall plate.

B. Wiring Devices Installed in Finished Spaces: Gray with stainless steel wall plate.

C. Wiring Devices Installed in Unfinished Spaces: Gray with galvanized steel wall plate.

D. Wiring Devices Installed in Wet or Damp Locations: Gray with specified weatherproof cover.

E. Wiring Devices Connected to Emergency Power: Red with stainless steel wall plate factory engraved "Emergency".

2.04 WALL SWITCHES

A. Manufacturers:

B. Wall Switches - General Requirements: AC only, quiet operating, general-use snap switches with silver alloy contacts, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 20 and where applicable, FS W-S-896; types as indicated on the drawings.

   1. Wiring Provisions: Terminal screws for side wiring and screw actuated binding clamp for back wiring with separate ground terminal screw.

C. Standard Wall Switches: Commercial specification grade, 20 A, 120/277 V with standard toggle type switch actuator and maintained contacts; single pole single throw, double pole single throw, three way, or four way as indicated on the drawings.

2.05 WALL DIMMERS

A. Manufacturers:
2. Wattstopper, a brand of Legrand North America, Inc

B. Wall Dimmers - General Requirements: Solid-state with continuous full-range even control following square law dimming curve, integral radio frequency interference filtering, power failure preset memory, air gap switch accessible without removing wall plate, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 1472; types and ratings suitable for load controlled as indicated on the drawings.

C. Control: Slide control type with separate on/off switch.

D. Power Rating, Unless Otherwise Indicated or Required to Control the Load Indicated on the Drawings:
   1. Match Load shown on drawings; 1200W minimum

E. Provide accessory wall switches to match dimmer appearance when installed adjacent to each other.

2.06 RECEPACTALES

A. Manufacturers:

B. Receptacles - General Requirements: Self-grounding, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 498, and where applicable, FS W-C-596; types as indicated on the drawings.
   1. NEMA configurations specified are according to NEMA WD 6.

C. Convenience Receptacles:
   1. Standard Convenience Receptacles: Commercial specification grade, 20A, 125V, NEMA 5-20R; single or duplex as indicated on the drawings.
   2. Weather Resistant Convenience Receptacles: Commercial specification grade, 20A, 125V, NEMA 5-20R, listed and labeled as weather resistant type complying with UL 498 Supplement SE suitable for installation in damp or wet locations; single or duplex as indicated on the drawings.

D. GFCI Receptacles:
   1. All GFI Receptacles: Provide with light to indicate ground fault tripped condition and loss of protection, and list as complying with UL 943, class A.
   3. Weather Resistant GFCI Receptacles: Commercial specification grade, duplex, 20A, 125V, NEMA 5-20R, rectangular decorator style, listed and labeled as weather resistant type complying with UL 498 Supplement SE suitable for installation in damp or wet locations.

2.07 WALL PLATES

A. Manufacturers:

B. Wall Plates: Comply with UL 514D.
   1. Configuration: One piece cover as required for quantity and types of corresponding wiring devices.
3. Screws: Metal with slotted heads finished to match wall plate finish.

C. Nylon Wall Plates: Smooth finish, high-impact thermoplastic.

D. Stainless Steel Wall Plates: Brushed satin finish, Type 302 stainless steel.

E. Galvanized Steel Wall Plates: Rounded corners and edges, with corrosion resistant screws.

F. Weatherproof Covers for Wet Locations: Gasketed, cast aluminum, with hinged lockable cover and corrosion-resistant screws; listed as suitable for use in wet locations while in use with attachment plugs connected and identified as extra-duty type.

2.08 FLOOR BOX SERVICE FITTINGS

A. Description: Service fittings compatible with floor boxes provided under Section 26 0534 with components, adapters, and trims required for complete installation.

B. Flush Floor Service Fittings:
   1. Dual Service Flush Combination Outlets:
      a. Cover: Rectangular.
      b. Configuration:
         1) As indicated in drawings.
   2. Accessories:
      a. Tile Rings: Finish to match covers; configuration as required to accommodate specified covers.
      b. Carpet Flanges: Finish to match covers; configuration as required to accommodate specified covers.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.

B. Verify that wall openings are neatly cut and will be completely covered by wall plates.

C. Verify that floor boxes are adjusted properly.

D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.

E. Verify that core drilled holes for poke-through assemblies are in proper locations.

3.02 PREPARATION

A. Provide extension rings to bring outlet boxes flush with finished surface.

B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

3.03 INSTALLATION

A. Perform work in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards unless otherwise indicated.

B. Coordinate locations of outlet boxes provided under Section 26 0534 as required for installation of wiring devices provided under this section.
   1. Mounting Heights: Unless otherwise indicated, as follows:
      a. Wall Switches: 48 inches above finished floor.
b. Wall Dimmers: 48 inches above finished floor.

c. Receptacles: 18 Inches above finished floor or 6 inches above counter, or 2” above backsplash.

d. Install Individual Telephone or Data outlet 18 Inches above finished floor.

e. Install Combo Tele/Data outlet 18 Inches above finished floor.

2. Orient outlet boxes for vertical installation of wiring devices unless otherwise indicated.

3. Where multiple receptacles, wall switches, or wall dimmers are installed at the same location and at the same mounting height, gang devices together under a common wall plate.

4. Locate wall switches on strike side of door with edge of wall plate 3 inches from edge of door frame. Where locations are indicated otherwise, notify Architect to obtain direction prior to proceeding with work.

C. Install wiring devices in accordance with manufacturer's instructions.

D. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.

E. Where required, connect wiring devices using pigtails not less than 6 inches long. Do not connect more than one conductor to wiring device terminals.

F. Connect wiring devices by wrapping conductor clockwise 3/4 turn around screw terminal and tightening to proper torque specified by the manufacturer. Where present, do not use push-in pressure terminals that do not rely on screw-actuated binding.

G. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.

H. Provide GFCI receptacles with integral GFCI protection at each location indicated. Do not use feed-through wiring to protect downstream devices.

I. Install wiring devices plumb and level with mounting yoke held rigidly in place.

J. Install wall switches with OFF position down.

K. Install wall dimmers to achieve full rating specified and indicated after derating for ganging as instructed by manufacturer.

L. Do not share neutral conductor on branch circuits utilizing wall dimmers.

M. Install vertically mounted receptacles with grounding pole on bottom and horizontally mounted receptacles with grounding pole on left.

N. Install wall plates to fit completely flush to wall with no gaps and rough opening completely covered without strain on wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough openings. Do not use oversized wall plates in lieu of meeting this requirement.

O. Install blank wall plates on junction boxes and on outlet boxes with no wiring devices installed or designated for future use.

P. Connect wiring device grounding terminal to outlet box with bonding jumper.

Q. Install decorative plates on switch, receptacle, and blank outlets in finished areas.

R. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface mounted outlets.
S. Install protective rings on active flush cover service fittings.

T. For all dedicated EWC receptacle, EC to rough-in behind water cooler shroud so no cords or plugs are visible when shroud is installed.

3.04 FIELD QUALITY CONTROL

A. Provide all test results to Engineer in Substantial Completion Submittals, via Architect, prior to scheduling Substantial Completion observations. Test results shall be tabulated to show name of tested device, measured value, expected values, acceptable standard deviation, and test conditions, as well as any miscellaneous variables that may be applicable to test being performed.

B. Inspect each wiring device for damage and defects.

C. Operate each wall switch with circuit energized to verify proper operation.

D. Verify that each receptacle device is energized.

E. Test each receptacle to verify operation and proper polarity.

F. Test each GFCI receptacle for proper tripping operation according to manufacturer's instructions.

G. Correct wiring deficiencies and replace damaged or defective wiring devices.

3.05 ADJUSTING

A. Adjust devices and wall plates to be flush and level.

3.06 CLEANING

A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

END OF SECTION
SECTION 26 2813
FUSES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Fuses.
B. Spare fuse cabinet.

1.02 RELATED REQUIREMENTS

A. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.
B. Section 26 2413 - Switchboards: Fusible switches.
C. Section 26 2816 - Enclosed Switches: Fusible switches.

1.03 REFERENCE STANDARDS

A. NEMA FU 1 - Low Voltage Cartridge Fuses; 2012.
B. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.04 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
1. Coordinate fuse clips furnished in equipment provided under other sections for compatibility with indicated fuses.
   a. Fusible Switches for Switchboards: See Section 26 2413.
   b. Fusible Enclosed Switches: See Section 26 2816.
2. Coordinate fuse requirements according to manufacturer's recommendations and nameplate data for actual equipment to be installed.

1.05 SUBMITTALS

A. See Section 26 0010 - General Electrical Requirements for submittal procedures.
B. Product Data: Provide manufacturer's standard data sheets including voltage and current ratings, interrupting ratings, time-current curves, and current limitation curves.
C. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. Extra Fuses: One set(s) of three for each type and size installed.
   2. Fuse Pullers: One set(s) compatible with each type and size installed.
   3. Spare Fuse Cabinet Keys: Two.
PART 2 PRODUCTS

2.01 MANUFACTURERS

2.02 APPLICATIONS
   A. Service Entrance:
      1. Fusible Switches up to 600 Amperes: Class RK1, time-delay.
      2. Fusible Switches Larger Than 600 Amperes: Class L, time-delay.
   B. General Purpose Branch Circuits: Class RK1, time-delay.
   C. Individual Motor Branch Circuits: Class RK1, time-delay.

2.03 FUSES
   A. Provide products listed, classified, and labeled as suitable for the purpose intended.
   B. Unless specifically indicated to be excluded, provide fuses for all fusible equipment as required for a complete operating system.
   C. Provide fuses of the same type, rating, and manufacturer within the same switch.
   D. Comply with UL 248-1.
   E. Unless otherwise indicated, provide cartridge type fuses complying with NEMA FU 1, Class and ratings as indicated.
   F. Voltage Rating: Suitable for circuit voltage.
   G. Class R Fuses: Comply with UL 248-12.
   H. Class L Fuses: Comply with UL 248-10.

2.04 SPARE FUSE CABINET
   A. Description: Wall-mounted sheet metal cabinet with shelves, suitably sized to store spare fuses and fuse pullers specified.
   B. Finish: Manufacturer’s standard, factory applied grey finish unless otherwise indicated.
   C. Doors: Hinged, with hasp for Owner’s padlock.
   D. Label in accordance with Section 16075.

PART 3 EXECUTION

3.01 EXAMINATION
   A. Verify that fuse ratings are consistent with circuit voltage and manufacturer’s recommendations and nameplate data for equipment.
   B. Verify that mounting surfaces are ready to receive spare fuse cabinet.
   C. Verify that conditions are satisfactory for installation prior to starting work.
3.02 INSTALLATION

A. Do not install fuses until circuits are ready to be energized.
B. Install fuses with label oriented such that manufacturer, type, and size are easily read.
C. Install spare fuse cabinet where indicated.
D. Provide identification nameplate for spare fuse cabinet in accordance with Section 26 0553.

END OF SECTION
SECTION 26 2816
ENCLOSED SWITCHES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Enclosed safety switches.
   1. Fusible switches.
   2. Nonfusible switches.

1.02 REFERENCE STANDARDS

A. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2014.
D. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
E. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations; Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the work with other trades. Avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and within working clearances for electrical equipment required by NFPA 70.
   2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
   3. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.

1.04 SUBMITTALS

A. See Section 26 0010 - General Electrical Requirements for submittal procedures.
B. Product Data: Provide manufacturer's standard catalog pages and data sheets for enclosed switches and other installed components and accessories.
C. Shop Drawings: Indicate outline and support point dimensions, voltage and current ratings, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
D. Field Quality Control Test Reports.
E. Project Record Documents: Record actual locations of enclosed switches.
F. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. See Section 26 2813 for requirements for spare fuses.
PART 2 PRODUCTS

2.01 MANUFACTURERS

D. Square D.
E. Source Limitations: Furnish enclosed switches and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

2.02 ENCLOSED SAFETY SWITCHES

A. Description: Quick-make, quick-break enclosed safety switches listed and labeled as complying with UL 98; heavy duty; ratings, configurations, and features as indicated on the drawings.
B. Provide products listed, classified, and labeled as suitable for the purpose intended.
C. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
   1. Altitude: Suitable for operation at 6,500 feet.
   2. Ambient Temperature: Between -22 degrees F and 104 degrees F.
D. Horsepower Rating: Suitable for connected load.
E. Voltage Rating: Suitable for circuit voltage.
F. Short Circuit Current Rating:
   1. Provide enclosed safety switches, when protected by the fuses or supply side overcurrent protective devices to be installed, with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings.
G. Provide with switch blade contact position that is visible when the cover is open.
H. Fuse Clips for Fusible Switches: As required to accept fuses indicated.
   1. Where NEMA Class R fuses are installed, provide rejection feature to prevent installation of fuses other than Class R.
I. Conductor Terminations: Suitable for use with the conductors to be installed.
J. Provide insulated, groundable fully rated solid neutral assembly where a neutral connection is required, with a suitable lug for terminating each neutral conductor.
K. Provide solidly bonded equipment ground bus in each enclosed safety switch, with a suitable lug for terminating each equipment grounding conductor.
L. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
   1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
      a. Indoor Clean, Dry Locations: Type 1.
      b. Outdoor Locations: Type 3R.
M. Provide safety interlock to prevent opening the cover with the switch in the ON position with capability of overriding interlock for testing purposes.

N. Heavy Duty Switches:
   2. Conductor Terminations:
      a. Lug Material: Copper, suitable for terminating copper conductors only.
   3. Provide externally operable handle with means for locking in the OFF position, capable of accepting three padlocks.

O. Provide the following features and accessories where indicated or where required to complete installation:
   1. Hubs: As required for environment type; sized to accept conduits to be installed.
   2. Integral fuse pullers.
   3. Where a remote disconnect is on the load side of a variable speed/frequency motor drive, ec to provide auxiliary contacts with break sensing to signal drive to switch to coast-to-stop mode. Control wiring and programming provided by supplier of drive.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Perform work in accordance with NECA 1 (general workmanship).

C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.

D. Provide required support and attachment in accordance with Section 26 0529.

E. Install enclosed switches plumb.

F. Except where indicated to be mounted adjacent to the equipment they supply, mount enclosed switches such that the highest position of the operating handle does not exceed 79 inches above the floor or working platform.

G. Provide grounding and bonding in accordance with Section 26 0526.

H. Provide fuses complying with Section 26 2813 for fusible switches as indicated or as required by equipment manufacturer's recommendations.

I. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.

J. Provide identification nameplate for each enclosed switch in accordance with Section 26 0553.

K. Provide identification label on inside door of each fused switch indicating NEMA fuse class and size installed in accordance with Section 26 0553.

L. Provide arc flash warning labels in accordance with NFPA 70.

M. Apply adhesive tag on inside door of each fused switch indicating NEMA fuse class and size installed.
3.02 FIELD QUALITY CONTROL

A. Provide all test results to Engineer in Substantial Completion Submittals, via Architect, prior to scheduling Substantial Completion observations. Test results shall be tabulated to show name of tested device, measured value, expected values, acceptable standard deviation, and test conditions, as well as any miscellaneous variables that may be applicable to test being performed.

B. Perform inspections and tests listed in NETA ATS, Section 7.5.1.1.

C. Correct deficiencies and replace damaged or defective enclosed safety switches or associated components.

3.03 ADJUSTING

A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

END OF SECTION
PART 1 GENERAL

1.01 SECTION INCLUDES

A. Enclosed NEMA controllers for low-voltage (600 V and less) applications:
   1. Magnetic motor starters.

B. Overcurrent protective devices for motor controllers, including overload relays.

C. Control accessories:
   1. Auxiliary contacts.
   2. Pilot devices.

1.02 REFERENCE STANDARDS

B. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2014.
D. NEMA KS 1 - Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum); 2013.
F. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
G. UL 98 - Enclosed and Dead-Front Switches; Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances required by NFPA 70.
   2. Coordinate the work to provide motor controllers and associated overload relays suitable for use with the actual motors to be installed.
   3. Coordinate the work to provide controllers and associated wiring suitable for interface with control devices to be installed.
   4. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
   5. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
1.04 SUBMITTALS

A. See Section 26 0010 - General Electrical Requirements for submittal procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for motor controllers, enclosures, overcurrent protective devices, and other installed components and accessories.

C. Field Quality Control Test Reports.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle carefully in accordance with manufacturer's written instructions to avoid damage to internal components, enclosure, and finish.

PART 2 PRODUCTS

2.01 MANUFACTURERS


2.02 ENCLOSED CONTROLLERS

A. Provide enclosed controller assemblies consisting of all required components, control power transformers, instrumentation and control wiring, accessories, etc. as necessary for a complete operating system.

B. Provide products listed, classified, and labeled as suitable for the purpose intended.

C. Description: Enclosed controllers complying with NEMA ICS 2, and listed and labeled as complying with UL 60947-1 and UL 60947-4-1; ratings, configurations and features as indicated on the drawings.

D. Service Conditions:
   1. Provide controllers and associated components suitable for operation under the following service conditions without derating:
      a. Altitude:
         1) Class 1 Km Equipment (devices utilizing power semiconductors, e.g. variable frequency controllers): Less than 3,300 feet.
         2) Class 2 Km Equipment (electromagnetic and manual devices): Less than 6,600 feet.
      b. Ambient Temperature: Between 32 degrees F and 104 degrees F.
   2. Provide controllers and associated components suitable for operation at indicated ratings under the service conditions at the installed location.

E. Short Circuit Current Rating:
   1. Provide controllers with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings.
F. Conductor Terminations: Suitable for use with the conductors to be installed.

G. Enclosures:
   2. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
      a. Indoor Clean, Dry Locations: Type 1 or Type 12.
      b. Outdoor Locations: Type 3R or Type 4.
   3. Finish: Manufacturer's standard unless otherwise indicated.

H. Instrument Transformers:
   2. Select suitable ratio, burden, and accuracy as required for connected devices.

I. Magnetic Motor Starters: Combination type unless otherwise indicated.
   1. Combination Magnetic Motor Starters: NEMA ICS 2, Class A combination motor controllers with magnetic contactor(s), externally operable disconnect and overload relay(s).
   2. Configuration: Full-voltage non-reversing unless otherwise indicated.
   3. Disconnects: Disconnect switch type.
      a. Disconnect Switches: Fusible type unless otherwise indicated.
      b. Provide externally operable handle with means for locking in the OFF position. Provide safety interlock to prevent opening the cover with the disconnect in the ON position with capability of overriding interlock for testing purposes.
      c. Provide auxiliary interlock for disconnection of external control power sources where applicable.
   4. Overload Relays: Bimetallic thermal type unless otherwise indicated.
   5. Pilot Devices Required:
      a. Furnish local pilot devices for each unit as specified below unless otherwise indicated on drawings.
      b. Single-Speed, Non-Reversing Starters:
         1) Selector Switches: HAND/OFF/AUTO.
         2) Indicating Lights: Red ON, Green OFF.

J. Manual Motor Starters:
   1. Description: NEMA ICS 2, Class A manually-operated motor controllers with overload relay(s).
   2. Configuration: Non-reversing unless otherwise indicated.
   3. Fractional-Horsepower Manual Motor Starters:
      a. Furnish with toggle operator.
      b. Overload Relays: Bimetallic or melting alloy thermal type.
      c. Provide means for locking operator in the OFF position.

2.03 OVERCURRENT PROTECTIVE DEVICES

A. Overload Relays:
   1. Provide overload relays and, where applicable, associated current elements/heaters, selected according to actual installed motor nameplate data, in accordance with manufacturer's recommendations and NFPA 70; include consideration for motor service factor and ambient temperature correction, where applicable.
2. Inverse-Time Trip Class Rating: Class 20 unless otherwise indicated or required.
3. Trip-free operation.
4. Visible trip indication.
5. Resettable.
   a. Employ manual reset unless otherwise indicated.
   b. Do not employ automatic reset with two-wire control.
6. Bimetallic Thermal Overload Relays:
   a. Interchangeable current elements/heaters.
   b. Adjustable trip; plus/minus 10 percent of nominal, minimum.
   c. Trip test function.
7. Melting Alloy Thermal Overload Relays:
   a. Interchangeable current elements/heaters.

B. Fusible Disconnect Switches:
   1. Description: Quick-make, quick-break, dead-front fusible switch units complying with NEMA KS 1, and listed and labeled as complying with UL 98; ratings, configurations, and features as indicated on the drawings.
   2. Fuse Clips: As required to accept indicated fuses.
   3. Provide externally operable handle with means for locking in the OFF position. Provide means for locking switch cover in the closed position. Provide safety interlock to prevent opening the cover with the switch in the ON position with capability of overriding interlock for testing purposes.

2.04 CONTROL ACCESSORIES

A. Auxiliary Contacts:
   1. Comply with NEMA ICS 5.
   2. Provide number and type of contacts indicated or required to perform necessary functions, including holding (seal-in) circuit and interlocking, plus one normally open (NO) and one normally closed (NC) spare contact for each magnetic motor starter, minimum.

B. Pilot Devices:
   1. Comply with NEMA ICS 5; heavy-duty type.
   2. Pushbuttons: Unless otherwise indicated, provide momentary, non-illuminated type with flush button operator; normally open or normally closed as indicated or as required.
   3. Selector Switches: Unless otherwise indicated, provide maintained, non-illuminated type with knob operator; number of switch positions as indicated or as required.
   4. Indicating Lights: Push-to-test type unless otherwise indicated.
   5. Provide LED lamp source for indicating lights and illuminated devices.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install products in accordance with manufacturer's instructions.
B. Install controllers in accordance with NECA 1 (general workmanship).
C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
D. Provide required support and attachment in accordance with Section 26 0529.
E. Install enclosed controllers plumb and level.
F. Provide grounding and bonding in accordance with Section 26 0526.
G. Install all field-installed devices, components, and accessories.
H. Provide fuses complying with Section 26 2813 for fusible switches as indicated.
I. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.
J. Set field-adjustable controllers and associated components according to installed motor requirements, in accordance with manufacturer's recommendations and NFPA 70.
K. Identify enclosed controllers in accordance with Section 26 0553.
L. Provide identification nameplate for each panelboard in accordance with Section 26 0553.
M. Provide neatly type label inside each motor controller door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating. Place label in clear plastic holder.
N. Provide arc flash warning labels in accordance with NFPA 70.
O. Where a remote disconnect is on the load side of a variable speed/frequency motor drive, etc to provide auxiliary contacts with break sensing to signal drive to switch to coast-to-stop mode. Control wiring and programming provided by supplier of drive.

3.02 FIELD QUALITY CONTROL
A. Provide all test results to Engineer in Substantial Completion Submittals, via Architect, prior to scheduling Substantial Completion observations. Test results shall be tabulated to show name of tested device, measured value, expected values, acceptable standard deviation, and test conditions, as well as any miscellaneous variables that may be applicable to test being performed.
B. Perform applicable inspections and tests listed in NETA STD ATS, except Section 4
C. Motor Starters: Perform inspections and tests listed in NETA ATS, Section 7.16.1.1. Tests listed as optional are not required.
D. Fusible Switches: Perform inspections and tests listed in NETA ATS, Section 7.5.1.1.
E. Correct deficiencies and replace damaged or defective enclosed controllers or associated components.

END OF SECTION
SECTION 26 5100
INTERIOR LIGHTING

PART 1 GENERAL

1.01 SECTION INCLUDES
A. Interior luminaires.
B. Exit signs.
C. Ballasts and drivers.
D. Lamps.

1.02 RELATED REQUIREMENTS
A. Section 26 0529 - Hangers and Supports.
B. Section 26 0534 - Boxes for Electrical Systems.
C. Section 26 0919 - Enclosed Contactors: Lighting contactors.
D. Section 26 2726 - Wiring Devices: Manual wall switches and wall dimmers.
E. Section 26 5600 - Exterior Lighting.

1.03 REFERENCE STANDARDS
E. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.04 ADMINISTRATIVE REQUIREMENTS
A. Coordination:
1. Coordinate the installation of luminaires with mounting surfaces installed under other sections or by others. Coordinate the work with placement of supports, anchors, etc. required for mounting. Coordinate compatibility of luminaires and associated trims with mounting surfaces at installed locations.
2. Coordinate the placement of luminaires with structural members, ductwork, piping, equipment, diffusers, fire suppression system components, and other potential conflicts installed under other sections or by others.
3. Coordinate the placement of exit signs with furniture, equipment, signage or other potential obstructions to visibility installed under other sections or by others.
4. Notify Architect of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

1.05 SUBMITTALS

A. See Section 26 0010 - General Electrical Requirements for submittal procedures.

B. Shop Drawings: Indicate dimensions and components for each fixture that is not a standard product of the manufacturer.

C. Product Data: Provide manufacturer's standard catalog pages and data sheets including detailed information on luminaire construction, dimensions, ratings, finishes, mounting requirements, listings, service conditions, photometric performance, installed accessories, and ceiling compatibility; include model number nomenclature clearly marked with all proposed features.
   1. LED Luminaires:
      a. Include estimated useful life, calculated based on IES LM-80 test data.

D. Operation and Maintenance Data: Instructions for each product including information on replacement parts.

E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. Extra Lenses and Louvers: Two percent of total quantity installed for each type, but not less than one of each type.
   2. Extra Lamps: Ten percent of total quantity installed for each type, but not less than two of each type.
   3. Extra Drivers: Two percent of total quantity installed for each type, but not less than one of each type.

1.06 QUALITY ASSURANCE

A. Conform to requirements of NFPA 70.

1.07 DELIVERY, STORAGE, AND PROTECTION

A. Receive, handle, and store products according to NECA/IESNA 500 (commercial lighting), NECA/IESNA 502 (industrial lighting), and manufacturer's written instructions.

B. Keep products in original manufacturer's packaging and protect from damage until ready for installation.

1.08 WARRANTY

A. Provide five year manufacturer warranty for all LED luminaires, including drivers.

B. Provide five year pro-rata warranty for batteries for emergency lighting units.

C. Provide ten year pro-rata warranty for batteries for self-powered exit signs.

PART 2 PRODUCTS

2.01 MANUFACTURERS - LUMINAIRES

A. As scheduled.

B. Acceptable equal. See Division 01 for substitution procedures.
2.02 LUMINAIRE TYPES
A. Furnish products as indicated in luminaire schedule included on the drawings.
B. See Section 26 0010 - General Electrical Requirements for submittal procedures.

2.03 LUMINAIRES
A. Provide products that comply with requirements of NFPA 70.
B. Provide products that are listed and labeled as complying with UL 1598, where applicable.
C. Provide products listed, classified, and labeled as suitable for the purpose intended.
D. Unless otherwise indicated, provide complete luminaires including lamp(s) and all sockets, ballasts, reflectors, lenses, housings and other components required to position, energize and protect the lamp and distribute the light.
E. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, hardware, supports, trims, accessories, etc. as necessary for a complete operating system.
F. Provide products suitable to withstand normal handling, installation, and service without any damage, distortion, corrosion, fading, discoloring, etc.
G. Recessed Luminaires:
   2. Luminaires Recessed in Insulated Ceilings: Listed and labeled as IC-rated, suitable for direct contact with insulation and combustible materials.
   3. Luminaires Recessed in Sloped Ceilings: Provide suitable sloped ceiling adapters.
H. LED Luminaires:
   1. Components: UL 8750 recognized or listed as applicable.
   2. Tested in accordance with IES LM-79 and IES LM-80.
   3. LED Estimated Useful Life: Minimum of 50,000 hours at 70 percent lumen maintenance, calculated based on IES LM-80 test data.

2.04 EMERGENCY LIGHTING UNITS
A. Description: Emergency lighting units complying with NFPA 101 and all applicable state and local codes, and listed and labeled as complying with UL 924.
B. Operation: Upon interruption of normal power source or brownout condition exceeding 20 percent voltage drop from nominal, solid-state control automatically switches connected lamps to integral battery power for minimum of 90 minutes of rated emergency illumination, and automatically recharges battery upon restoration of normal power source.
C. Battery:
   1. Size battery to supply all connected lamps, including emergency remote heads where indicated.
D. Diagnostics: Provide power status indicator light and accessible integral test switch to manually activate emergency operation.
E. Provide low-voltage disconnect to prevent battery damage from deep discharge.
F. Accessories:
1. Provide compatible accessory mounting brackets where indicated or required to complete installation.
2. Where indicated, provide emergency remote heads that are compatible with the emergency lighting unit they are connected to and suitable for the installed location.

2.05 EXIT SIGNS

A. Description: Internally illuminated exit signs with LEDs unless otherwise indicated; complying with NFPA 101 and all applicable state and local codes, and listed and labeled as complying with UL 924.
   1. Number of Faces: Single or double as indicated or as required for the installed location.
   2. Directional Arrows: As indicated or as required for the installed location.

B. Self-Powered Exit Signs:
   1. Operation: Upon interruption of normal power source or brownout condition exceeding 20 percent voltage drop from nominal, solid-state control automatically switches connected lamps to integral battery power for minimum of 90 minutes of rated emergency illumination, and automatically recharges battery upon restoration of normal power source.
   2. Diagnostics: Provide power status indicator light and accessible integral test switch to manually activate emergency operation.
   3. Provide low-voltage disconnect to prevent battery damage from deep discharge.

2.06 BALLASTS AND DRIVERS

A. Manufacturers:
   2. OSRAM Sylvania, Inc: www.osram.us/ds/#sle.

B. Dimmable LED Drivers:
   1. Dimming Range: Continuous dimming from 100 percent to five percent relative light output unless dimming capability to lower level is indicated, without flicker.
   2. Control Compatibility: Fully compatible with the dimming controls to be installed.
      a. Wall Dimmers: See Section 26 2726.

2.07 LAMPS

A. Lamps - General Requirements:
   1. Unless explicitly excluded, provide new, compatible, operable lamps in each luminaire.
   2. Verify compatibility of specified lamps with luminaires to be installed. Where lamps are not specified, provide lamps per luminaire manufacturer's recommendations.
   3. Minimum Efficiency: Provide lamps complying with all current applicable federal and state lamp efficiency standards.
   4. Color Temperature Consistency: Unless otherwise indicated, for each type of lamp furnish products which are consistent in perceived color temperature. Replace lamps that are determined by the Architect to be inconsistent in perceived color temperature.

B. LED:
   1. Light Loss: L70 equal to or greater than 50,000 hrs.
   2. Color temperature of 4,000k.
   3. Color Shift within a 3-step ellipse.
   4. Luminaire performance based on 25 degree ambient temperature.
   5. Power Factor greater .85 or better.
PART 3 EXECUTION

3.01 INSTALLATION

A. Coordinate locations of outlet boxes provided under Section 26 0534 as required for installation of luminaires provided under this section.

B. Install products in accordance with manufacturer's instructions.

C. Install luminaires securely, in a neat and workmanlike manner, as specified in NECA 500 (commercial lighting) and NECA 502 (industrial lighting).

D. Provide required support and attachment in accordance with Section 26 0529.

E. Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.

F. Suspended Ceiling Mounted Luminaires:
   1. Do not use ceiling tiles to bear weight of luminaires.
   2. Secure surface-mounted and recessed luminaires to ceiling support channels or framing members or to building structure.
   3. Secure lay-in luminaires to ceiling support channels using listed safety clips at four corners.
   4. In addition to ceiling support wires, provide two galvanized steel safety wire(s), minimum 12 gage, connected from opposing corners of each recessed luminaire to building structure.
   5. See appropriate Division 9 section where suspended grid ceiling is specified for additional requirements.

G. Recessed Luminaires:
   1. Install trims tight to mounting surface with no visible light leakage.
   2. Non-IC Rated Luminaires: Maintain required separation from insulation and combustible materials according to listing.
   3. Luminaires Recessed in Fire-Rated Ceilings: Install using accessories and firestopping materials to meet regulatory requirements for fire rating.

H. Suspended Luminaires:
   1. Unless otherwise indicated, specified mounting heights are to bottom of luminaire.
   2. Install using the suspension method indicated, with support lengths and accessories as required for specified mounting height.
   3. Provide minimum of two supports for each luminaire equal to or exceeding 4 feet nominal length, with no more than 4 feet between supports.
   4. Install canopies tight to mounting surface.

I. Wall-Mounted Luminaires: Unless otherwise indicated, specified mounting heights are to center of luminaire.

J. Install fixtures securely, in a neat and workmanlike manner, as specified in NECA 500 (commercial lighting).

K. Surface Mounted Fixtures: Install plumb and square and aligned with building lines and with each other; secure to prevent movement.

L. Wall Mounted Fixtures: Install at height as indicated on the drawings.

M. Locate recessed ceiling luminaires as indicated on lighting plans.

N. Install accessories furnished with each luminaire.
O. Make wiring connections to branch circuit using building wire with insulation suitable for temperature conditions within fixture.

P. Bond products and metal accessories to branch circuit equipment grounding conductor.

Q. Emergency Lighting Units:
   1. Unless otherwise indicated, connect unit to unswitched power from same circuit feeding normal lighting in same room or area. Bypass local switches, contactors, or other lighting controls.

R. Exit Signs:
   1. Unless otherwise indicated, connect unit to unswitched power from same circuit feeding normal lighting in same room or area. Bypass local switches, contactors, or other lighting controls.

S. Install lamps in each luminaire.

3.02 FIELD QUALITY CONTROL

A. Inspect each product for damage and defects.

B. Operate each luminaire after installation and connection to verify proper operation.

C. Test fluorescent emergency power supply units to verify proper operation upon loss of normal power supply.

D. Correct wiring deficiencies and repair or replace damaged or defective products. Repair or replace excessively noisy ballasts as determined by Architect.

3.03 ADJUSTING

A. Aim and position adjustable luminaires to achieve desired illumination as indicated or as directed by Owner. Secure locking fittings in place.

B. Aim and position adjustable emergency lighting unit lamps to achieve optimum illumination of egress path as required or as directed by Architect or authority having jurisdiction.

C. Exit Signs with Field-Selectable Directional Arrows: Set as indicated or as required to properly designate egress path as directed by Architect or authority having jurisdiction.

D. Aim and adjust fixtures as indicated.

3.04 CLEANING

A. Clean surfaces according to NECA 500 (commercial lighting) and manufacturer’s instructions to remove dirt, fingerprints, paint, or other foreign material and restore finishes to match original factory finish.

B. Clean electrical parts to remove conductive and deleterious materials.

C. Remove dirt and debris from enclosures.

D. Clean finishes and touch up damage.

3.05 CLOSEOUT ACTIVITIES

A. Just prior to Substantial Completion, replace all lamps that have failed.

END OF SECTION
SECTION 26 5600
EXTERIOR LIGHTING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Exterior luminaires.
B. Ballasts.
C. Lamps.
D. Poles and accessories.

1.02 RELATED REQUIREMENTS

A. Section 03 3000 - Cast-in-Place Concrete: Materials and installation requirements for concrete bases for poles.
B. Section 26 0526 - Grounding and Bonding.
C. Section 26 0529 - Hangers and Supports.
D. Section 26 0534 - Boxes for Electrical Systems.
E. Section 26 0650.16 - Lighting Fixture Schedule.
F. Section 26 0919 - Enclosed Contactors: Lighting contactors.
G. Section 26 2726 - Wiring Devices: Receptacles for installation in poles.

1.03 REFERENCE STANDARDS

D. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
F. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.04 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate placement of poles and associated foundations with utilities, curbs, sidewalks, trees, walls, fences, striping, etc. installed under other sections or by others. Coordinate elevation to obtain specified foundation height.
   2. Notify Architect of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.
3. Furnish bolt templates and pole mounting accessories to installer of pole foundations.

1.05 SUBMITTALS

A. See Section 26 0010 - General Electrical Requirements for submittal procedures.

B. Shop Drawings: Indicate dimensions and components for each luminaire that is not a standard product of the manufacturer.

C. Product Data: Provide manufacturer's standard catalog pages and data sheets including detailed information on luminaire construction, dimensions, ratings, finishes, mounting requirements, listings, service conditions, photometric performance, weight, effective projected area (EPA), and installed accessories; include model number nomenclature clearly marked with all proposed features.
   1. LED Luminaires: 
      a. Include estimated useful life, calculated based on IES LM-80 test data.

D. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. Extra Lamps: Ten percent of total quantity installed for each type, but not less than two of each type.
   2. Extra Ballasts: Two percent of total quantity installed for each type, but not less than one of each type.

E. Project Record Documents: Record actual connections and locations of pole foundations, luminaires, and any pull or junction boxes.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Receive, handle, and store products according to NECA/IESNA 501 and manufacturer's written instructions.

B. Keep products in original manufacturer’s packaging and protect from damage until ready for installation.

PART 2 PRODUCTS

2.01 LUMINAIRE TYPES

A. Furnish products as indicated in luminaire schedule included on the Drawings.

2.02 LUMINAIRE

A. Provide products that comply with requirements of NFPA 70.

B. Provide products that are listed and labeled as complying with UL 1598, where applicable.

C. Provide products listed, classified, and labeled as suitable for the purpose intended.

D. Unless otherwise indicated, provide complete luminaires including lamp(s) and all sockets, ballasts, reflectors, lenses, housings and other components required to position, energize and protect the lamp and distribute the light.

E. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, hardware, poles, foundations, supports, trims, accessories, etc. as necessary for a complete operating system.

F. Provide products suitable to withstand normal handling, installation, and service without any damage, distortion, corrosion, fading, discoloring, etc.

G. Provide luminaires listed and labeled as suitable for wet locations unless otherwise indicated.
H. LED Luminaires:
   1. Components: UL 8750 recognized or listed as applicable.
   2. Tested in accordance with IES LM-79 and IES LM-80.
   3. LED Estimated Useful Life: Minimum of 50,000 hours at 70 percent lumen maintenance, calculated based on IES LM-80 test data.

2.03 BALLASTS

A. Ballasts/Drivers - General Requirements:
   1. Provide ballasts containing no polychlorinated biphenyls (PCBs).
   2. Minimum Efficiency/Efficacy: Provide ballasts complying with all current applicable federal and state ballast efficiency/efficacy standards.

2.04 LAMPS

A. Lamps - General Requirements:
   1. Unless explicitly excluded, provide new, compatible, operable lamps in each luminaire.
   2. Verify compatibility of specified lamps with luminaires to be installed. Where lamps are not specified, provide lamps per luminaire manufacturer's recommendations.
   3. Minimum Efficiency: Provide lamps complying with all current applicable federal and state lamp efficiency standards.
   4. Color Temperature Consistency: Unless otherwise indicated, for each type of lamp furnish products which are consistent in perceived color temperature. Replace lamps that are determined by the Architect to be inconsistent in perceived color temperature.

B. LED:
   1. Light Loss: L70 equal to or greater than 50,000 hrs.
   2. Color temperature of 4,000k.
   3. Color Shift within a 3-step ellipse.
   4. Luminaire performance based on 25 degree ambient temperature.

2.05 POLES

A. All Poles:
   1. Provide poles and associated support components suitable for the luminaire(s) and associated supports and accessories to be installed.
   2. Structural Design Criteria:
      a. Wind Load: Include effective projected area (EPA) of luminaire(s) and associated supports and accessories to be installed.
         1) Design Wind Speed: _______ miles per hour, with gust factor of 1.3.
   3. Material: Steel, unless otherwise indicated.
   4. Shape: Square straight, unless otherwise indicated.
   5. Finish: Match luminaire finish, unless otherwise indicated.
   6. Mounting: Install on concrete foundation, height as indicated on the drawings, unless otherwise indicated.
   7. Unless otherwise indicated, provide with the following features/accessories:
      a. Top cap.
      b. Handhole.
      c. Anchor bolts with leveling nuts or leveling shims.
      d. Anchor base cover.

B. Metal Poles: Provide ground lug, accessible from handhole.
PART 3 EXECUTION

3.01 INSTALLATION

A. Coordinate locations of outlet boxes provided under Section 26 0534 as required for installation of luminaires provided under this section.

B. Install products in accordance with manufacturer’s instructions.

C. Install luminaires in accordance with NECA/IESNA 501.

D. Provide required support and attachment in accordance with Section 26 0529.

E. Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.

F. Wall-Mounted Luminaires: Unless otherwise indicated, specified mounting heights are to center of luminaire.

G. Pole-Mounted Luminaires:
   1. Maintain the following minimum clearances:
      b. Comply with utility company requirements.
   2. Foundation-Mounted Poles:
      a. Provide cast-in-place concrete foundations for poles as indicated, in accordance with Section 03 3000.
         1) Install anchor bolts plumb per template furnished by pole manufacturer.
         2) Position conduits to enter pole shaft.
      b. Install foundations plumb.
      c. Install poles plumb, using leveling nuts or shims as required to adjust to plumb.
      d. Tighten anchor bolt nuts to manufacturer’s recommended torque.
      e. Install non-shrink grout between pole anchor base and concrete foundation, leaving small channel for condensation drainage.
      f. Install anchor base covers or anchor bolt covers as indicated.
   3. Grounding:
      a. Bond luminaires, metal accessories, metal poles, and foundation reinforcement to branch circuit equipment grounding conductor.
   4. Install separate service conductors, 12 AWG copper, from each luminaire down to handhole for connection to branch circuit conductors.

H. Install accessories furnished with each luminaire.

I. Bond products and metal accessories to branch circuit equipment grounding conductor.

J. Install lamps in each luminaire.

3.02 FIELD QUALITY CONTROL

A. Inspect each product for damage and defects.

B. Operate each luminaire after installation and connection to verify proper operation.

C. Correct wiring deficiencies and repair or replace damaged or defective products. Repair or replace excessively noisy ballasts as determined by Architect/Architect.
3.03 ADJUSTING
   A. Aim and position adjustable luminaires to achieve desired illumination as indicated or as directed by Architect. Secure locking fittings in place.

3.04 CLEANING
   A. Clean surfaces according to NECA/IESNA 501 and manufacturer's instructions to remove dirt, fingerprints, paint, or other foreign material and restore finishes to match original factory finish.
   B. Clean electrical parts to remove conductive and deleterious materials.
   C. Remove dirt and debris from enclosure.
   D. Clean finishes and touch up damage.

3.05 CLOSEOUT ACTIVITIES
   A. Just prior to Substantial Completion, replace all lamps that have failed.

END OF SECTION
SECTION 27 1000
STRUCTURED CABLING AND EQUIPMENT FOR VOICE AND DATA

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Communications pathways.
B. Copper cable and terminations.
C. Fiber optic cable and interconnecting devices.
D. Communications equipment room fittings.
E. Communications outlets.
F. Communications grounding and bonding.
G. Communications identification.
H. Telecommunications service entrance to building(s).

1.02 RELATED REQUIREMENTS

A. Section 26 0526 - Grounding and Bonding.
B. Section 26 0533 - Conduit for Electrical Systems.
C. Section 26 0536 - Cable Trays for Electrical Systems.
D. Section 26 0534 - Boxes for Electrical Systems.
E. Section 26 2726 - Wiring Devices.

1.03 REFERENCE STANDARDS

A. EIA/ECA-310 - Cabinets, Racks, Panels, and Associated Equipment; Electronic Industries Alliance/Electrical Components Association; Revision E, 2005.
B. EIA-310 - Cabinets, Racks, Panels, and Associated Equipment; Electronic Industries Association; Revision D, 1992.
D. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
F. TIA-568.2 - Balanced Twisted-Pair Telecommunications Cabling and Components Standards; 2009c, with Addendum (2016).
G. TIA-569 - Telecommunications Pathways and Spaces; 2015d, with Addendum (2016).
H. TIA-606 - Administration Standard for Telecommunications Infrastructure; 2017c.


M. ANSI/J-STD-607 - Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.


O. UL 1863 - Communications-Circuit Accessories; Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate requirements for service entrance and entrance facilities with Communications Service Provider.
   2. Coordinate the work with other trades to avoid placement of other utilities or obstructions within the spaces dedicated for communications equipment.
   3. Coordinate arrangement of communications equipment with the dimensions and clearance requirements of the actual equipment to be installed.
   4. Notify architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.05 SUBMITTALS

A. Product Data: Manufacturer's data sheets on each product to be used (Cables, Racks, Switches, Outlets, etc.).
   1. Storage and handling requirements and recommendations.
   2. Installation methods.

B. Test Plan: Complete and detailed plan, with list of test equipment, procedures for inspection and testing, and intended test date; submit at least 60 days prior to intended test date.

C. Field Test Reports.

D. Project Record Documents:
   1. Record actual locations of outlet boxes and distribution frames.
   2. Show as-installed color coding, pair assignment, polarization, and cross-connect layout.
   3. Identify distribution frames and equipment rooms by room number on drawings.

E. Operation and Maintenance Data: List of all components with part numbers, sources of supply, and operation and maintenance instructions; include copy of project record documents.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: A company having at least 3 years experience in the installation and testing of the type of system specified, and:
   1. Supervisors and installers factory certified by manufacturers of products to be installed.
   2. Employing experienced technicians for all work; show at least 3 years experience in the installation of the type of system specified, with evidence from at least 2 projects that have been in use for at least 18 months; submit project name, address, and written certification by user.
1.07 DELIVERY, STORAGE, AND HANDLING
A. Store products in manufacturer’s unopened packaging until ready for installation.
B. Keep stored products clean and dry.

1.08 WARRANTY
A. Correct defective Work within a 2 year period after Date of Substantial Completion.
B. Substitute products must meet the following ICC warranties.
   1. 3-Year Limited Product Warranty
      a. Warrant products to be free from defects in material and workmanship for 3 years from the date of original purchase.
   2. 15-Year Performance Limited Warranty
      a. Guaranteed system performance from end-to-end for 15 years from the date of installation for Elite Installers. Coverage includes the replacement of ICC products only. You don’t have to be certified and no training is needed. This 15-year performance warranty covers end-to-end projects using ICC category-rated connectivity products and premise cables. This 15-year Performance Limited Warranty does not cover fiber optic product installation.
   3. Lifetime Performance Limited Warranty
      a. Guaranteed system performance from end-to-end for the usable life of the cabling system. Coverage includes replacement of ICC products and labor to replace them. This structured cabling system must be installed by a Certified Elite Installer with ICC category-rated connectivity products plus ICC horizontal premise cable as an end-to-end PermanentLink solution. Submit Lifetime Verified Site Form prior to the installation. The site must be verified as an ICC Verified Site Cabling System. This Lifetime Performance Limited Warranty does not cover fiber optic product installation.

PART 2 PRODUCTS

2.01 MANUFACTURERS
A. Cabling:
   1. Integrated Communications Cabling (ICC). www.icc.com/
   2. Acceptable Equal
B. Equipment:
   1. Integrated Communications Cabling (ICC). www.icc.com/
   2. Acceptable Equal

2.02 SYSTEM DESIGN
A. Provide a complete, permanent system of cabling and pathways for voice and data communications, including conduits and wireways, pull wires, support structures, enclosures and cabinets.
   1. Comply with TIA-568 (SET) (cabling) and TIA-569 (pathways) (commercial standards).
   2. Provide fixed conduits and pathways that comply with NFPA 70 and ANSI/J-STD-607 and are UL listed or third party independent testing laboratory certified.
   3. Provide connection devices that are rated for operation under conditions of 32 to 140 degrees F at relative humidity of 0 to 95 percent, noncondensing.
   4. In this project, the term plenum is defined as return air spaces above ceilings, inside ducts, under raised floors, and other air-handling spaces.
   5. Provide a separate cable for every jack indicted, both in single and multiple jack outlet combinations.
B. System Description:
   1. Building Entrance Cable: Existing.
   2. Horizontal Cabling: Copper.

C. Main Distribution Frame (MDF): Centrally located support structure for terminating backbone cables and horizontal cables that extend to telecommunications outlets, functioning as point of presence to external service provider.

D. Intermediate Distribution Frames (IDF): Support structures for terminating horizontal cables that extend to telecommunications outlets.

E. Backbone Cabling: Cabling, pathways, and terminal hardware connecting intermediate distribution frames (IDF's) with main distribution frame (MDF), wired in star topology with main distribution frame at center hub of star.

F. Cabling to Outlets: Specified horizontal cabling, wired in star topology to distribution frame located at center hub of star; also referred to as "links".

2.03 PATHWAYS

A. Conduit: As specified in Section 26 05 34.
   1. Provide pull cords in all empty conduit

2.04 COPPER CABLE AND TERMINATIONS

A. Copper Horizontal Cable:
   1. Description: 100 ohm, balanced twisted pair cable complying with TIA-568.2 and listed and labeled as complying with UL 444.
   2. Cable Type - Voice and Data: TIA-568 Category 6 UTP (unshielded twisted pair); 23 AWG.
   3. Cable Capacity: 4-pair.
   4. Cable Applications:
      a. Plenum Applications: Use listed NFPA 70 Type CMP plenum cable.
      b. General Purpose Applications: Use listed NFPA 70 Type CM/CMG general purpose cable, Type CMR riser cable, or Type CMP plenum cable.
   5. Cable Jacket Color - Voice and Data Cable: Blue.

B. Copper Cable Terminations: Insulation displacement connection (IDC) type using appropriate tool; use screw connections only where specifically indicated.

C. Jacks and Connectors: Modular RJ-45, non-keyed, terminated with 110-style insulation displacement connectors (IDC); high impact thermoplastic housing; suitable for and complying with same standard as specified horizontal cable; UL 1863 listed.
   1. Performance: 750 mating cycles.
   2. Voice and Data Jacks: 8-position modular jack, color-coded for both T568A and T568B wiring configurations.

D. Copper Patch Cords:
   1. Description: Factory-fabricated 4-pair cable assemblies with 8-position modular connectors terminated at each end.
   2. Patch Cords for Patch Panels:
      a. Quantity: One for each pair of patch panel ports.

2.05 COMMUNICATIONS EQUIPMENT ROOM FITTINGS

A. Copper Cross-Connection Equipment:
1. Connector Blocks for Category 6 Cabling: Type 110 insulation displacement connectors; capacity sufficient for cables to be terminated plus 25 percent spare.
2. Patch Panels for Copper Cabling: Sized to fit EIA/ECA-310 standard 19 inch wide equipment racks; 0.09 inch thick aluminum; cabling terminated on Type 110 insulation displacement connectors; printed circuit board interface.
   a. Jacks: Non-keyed RJ-45, suitable for and complying with same standard as cable to be terminated; maximum 48 ports per standard width panel.
   b. Capacity: Provide ports sufficient for cables to be terminated plus 25 percent spare.
   c. Labels: Factory installed laminated plastic nameplates above each port, numbered consecutively; comply with TIA-606.
   d. Provide incoming cable strain relief and routing guides on back of panel.

B. Backboards: Interior grade plywood without voids, 3/4 inch thick; UL-labeled fire-retardant.
   1. Size: 48 by 96 inches.
   2. Do not paint over UL label.

C. Equipment Frames, Racks and Cabinets:
   2. Wall Mounted Racks: Steel construction, hinged to allow access to back of installed components.

2.06 COMMUNICATIONS OUTLETS

A. Outlet Boxes: Comply with Section 26 0534.
   1. Provide depth as required to accommodate cable manufacturer's recommended minimum conductor bend radius.
   2. Minimum Size, Unless Otherwise Indicated:
      a. Voice Only Outlets: 4 inch by 2 inch by 2-1/8 inch deep (100 by 50 by 54 mm) trade size.
      b. Data or Combination Voice/Data Outlets: 4 inch square by 2-1/8 inch deep (100 by 54 mm) trade size.

B. Wall Plates:
   1. Comply with system design standards and UL 514C.
   2. Accepts modular jacks/inserts.
   3. Wall Plate Material/Finish - Flush-Mounted Outlets: Match wiring device and wall plate finishes specified in Section 26 2726.

2.07 GROUNDING AND BONDING COMPONENTS

A. Comply with TIA-607.

2.08 IDENTIFICATION PRODUCTS

A. Comply with TIA-606.

PART 3 EXECUTION

3.01 INSTALLATION - GENERAL

A. Comply with latest editions and addenda of TIA-568 (SET) (cabling), TIA-569 (pathways), TIA-607 (grounding and bonding), NECA/BICSI 568, NFPA 70, and SYSTEM DESIGN as specified in PART 2.

B. Comply with Communication Service Provider requirements.

C. Grounding and Bonding: Perform in accordance with TIA-607 and NFPA 70.
3.02 INSTALLATION OF PATHWAYS

A. Install pathways with the following minimum clearances:
   1. 48 inches from motors, generators, frequency converters, transformers, x-ray equipment, and uninterruptible power systems.
   2. 12 inches from power conduits and cables and panelboards.
   3. 5 inches from fluorescent and high frequency lighting fixtures.
   4. 6 inches from flues, hot water pipes, and steam pipes.

B. Conduit:
   1. Provide conduit in all inaccessible areas, crawlspaces, walls, and where exposed to view unless indicated below.
      a. Do not install more than 2 (two) 90 degree bends in a single horizontal cable run.
      b. Leave pull cords in place where cables are not initially installed.
      c. Conceal conduit under floor slabs and within finished walls, ceilings, and floors except where specifically indicated to be exposed.
         1) Conduit may remain exposed to view in mechanical rooms, electrical rooms, and telecommunications rooms.
         2) Where exposed to view, install parallel with or at right angles to ceilings, walls, and structural members.

C. Outlet Boxes:
   1. Coordinate locations of outlet boxes provided under Section 26 0534 as required for installation of telecommunications outlets provided under this section.
      a. Mounting Heights:  Unless otherwise indicated, as follows:
         1) Telephone and Data Outlets: 18 inches above finished floor.
         2) Telephone Outlets for Forward-Reach Wall-Mounted Telephones: 48 inches above finished floor to top of telephone.

3.03 INSTALLATION OF EQUIPMENT AND CABLING

A. Cabling:
   1. Do not bend cable at radius less than manufacturer's recommended bend radius; for unshielded twisted pair use bend radius of not less than 4 times cable diameter.
   2. Do not over-cinch or crush cables.
   3. Do not exceed manufacturer's recommended cable pull tension.
   4. When installing in conduit, use only lubricants approved by cable manufacturer and do not chafe or damage outer jacket.

B. Service Loops (Slack or Excess Length): Provide the following minimum extra length of cable, looped neatly:
   1. At Distribution Frames: 60 inches.
   2. At Outlets - Copper: 12 inches.

C. Copper Cabling:
   1. Category 5e/6/6A: Maintain cable geometry; do not untwist more than 1/2 inch from point of termination.
   2. For 4-pair cables in conduit, do not exceed 25 pounds pull tension.
   3. Use T568B wiring configuration.
   4. Copper Cabling Not in Conduit: Use only type CMP plenum-rated cable as specified.
   5. For all cable, provide NFPA 70 type CMP plenum-rated cable.
D. Wall-Mounted Racks and Enclosures:
   1. Install to plywood backboards only, unless otherwise indicated.
   2. Mount so height of topmost panel does not exceed 78 inches above floor.

E. Field-Installed Labels: Comply with TIA/EIA-606 using encoded identifiers.
   1. Cables: Install color coded labels on both ends.
   2. Outlets: Label each jack on its face plate as to its type and function, with a unique numerical identifier as directed by owners IT personnel.
   3. Patch Panels: Label each jack as to its type and function, with a unique numerical identifier as directed by owners IT personnel.

F. Install all equipment listed above in racks at locations coordinated by owner IT representative.

3.04 FIELD QUALITY CONTROL
A. EC to provide all testing. Comply with inspection and testing requirements of specified installation standards.

B. Visual Inspection:
   1. Inspect cable jackets for certification markings.
   2. Inspect cable terminations for color coded labels of proper type.
   3. Inspect outlet plates and patch panels for complete labels.

C. Testing - Copper Cabling and Associated Equipment:
   1. Cables Must be Verified using a Calibrated and Certified Tester to the following spec. ANSI TIA 1152-A Level 2G, ISO IEC 61935-1 Edition 5 Level 6. Low Voltage Contractor to provide copy of current cable tester calibration and each cable needs to be certified and pass with a printed and PDF result for each cable.
   2. Test backbone cables after termination but before cross-connection.
   3. Test backbone cables for DC loop resistance, shorts, opens, intermittent faults, and polarity between connectors and between conductors and shield, if cable has overall shield.
   4. Test operation of shorting bars in connection blocks.
   5. Category 6 Backbone: Perform near end cross talk (NEXT) and attenuation tests.

D. Final Testing: After all work is complete, including installation of telecommunications outlets, and telephone dial tone service is active, test each voice jack for dial tone.
   1. Provide a copy of the copper and fiber optic certification with the O&M manuals.

END OF SECTION
PART 1 GENERAL

1.01 SUMMARY

A. Contract Documents

1. The General and Special Conditions are hereby made a part of this Section. Where requirements of this Section are at odds with requirements stated in any Special or Supplementary Conditions, the more stringent requirements shall apply.

2. The Contract Documents are complementary and are intended to include or imply all items required for the proper execution and completion of the work. Any item or work required by the Specification or other portion of the Contract Documents, but not shown on the drawings, or shown on the drawings but not described in the Specification, shall be provided and installed by the Contractor as if shown or mentioned in both.

3. The Consultant may furnish additional instruction or clarification necessary for the proper execution of the work. Instructions or clarifications shall be consistent with the Contract Documents or agreed upon modifications thereof, and inferable therefrom. In giving instruction or clarification, only the Contracting Officer shall have the authority to make minor changes in the work that will not entail an increase in the Contract price or time.

4. Copies of drawings and specifications, regardless of how furnished, are the property of the Owner and are not to be used on any other work or project. No contract documents may be released for publication or to any other party without the written consent of the Owner and Consultant.

B. Scope of Work

1. Work under this Contract includes the following spaces/systems:

2. Casper/Natrona County International Airport


4. Work under this Contract includes all labor, materials, tools and equipment, transportation services, supervision, coordination, etc., necessary to complete the installation of high quality A/V Systems and Control Systems, in excellent working order, as described in these specifications and the associated drawings and in accordance with good engineering practice, and to maintain the systems throughout the Warranty period.

5. The systems defined herein shall be called "A/V Systems" and shall include, but are not limited to, the following major items:

6. Audio mixers, equalizers, amplifiers, program sources, digital recording devices, microphones and other signal processing equipment;

7. Loudspeakers and loudspeaker mounting, aiming, rigging, and support hardware;

8. Video switching, video over IP transmitters/receivers, video display equipment, video conferencing systems, cameras, and other video playback devices.

9. Audio Video and Control Network equipment;

10. Control equipment;
11. Equipment racks, cabinetry, and furniture;
12. System accessories;
13. Cable, connectors, adapters, plates, panels, transformers, and other interface devices.
14. The Contract also includes:
15. Verification of dimensions and conditions at the job site.
17. Installation in accordance with the contract documents, manufacturer’s recommendations, and all applicable code and legal requirements.
18. Initial tests and adjustments, written report, demonstration for approval, final adjustments, and documentation.
19. Instruction of operating personnel; provision of manuals.
20. Maintenance services; Warranty.
21. Notwithstanding any detailed information in the Contract Documents, it is the responsibility of the A/V System Contractor to supply systems in full working order, and of the Owner and A/V System Contractor to meet all code requirements for the installation of conduit and cable, respectively.
22. Notify the Consultant of any discrepancies in part numbers, sizes, or quantities before bid. Failing to provide such notification, supply items, sizes, and quantities according to the intent of the design as described in the Specifications and Drawings, without claim for additional payment.
23. Supply accessories and minor equipment items needed for a complete and properly functioning system, or where required to meet the specified performance, even if not specifically mentioned herein or on the drawings, without claim for additional payment.
24. Distribute AC power within all equipment racks and furniture supplied herein. As required, provide all AC power cable, conduit, wireways, junction boxes, power distribution units, and/or receptacles located in equipment racks or furniture provided by the A/V System Contractor. This shall also include any power cabling from A/V equipment racks or furniture to adjacent receptacles or junction box(es) unless otherwise noted.

C. Products Supplied but Not Installed Under This Section

1. Certain equipment may be supplied but not installed or may be determined as “installed by others” (e.g. Electrical Contractor, General Contractor, etc.) or “installed by owner.” This may include but not be limited to portable equipment and/or cables.
   a. As part of the project, all ceiling tiles (both new and replacement) shall be provided by the General Contractor or one of their designated subcontractors.

D. Products Installed But Not Supplied Under This Section

1. Certain equipment may be identified after the bid is awarded as Owner Furnished Equipment (OFE). Owner Furnished Equipment is presently part of the Owner's system, or will be provided by the Owner, and will be delivered to Contractor's off-site construction facility, delivered to the Contractor's on-site secured storage area, or otherwise provided on site, as appropriate, for incorporation into the system.
2. Inspect the OFE, and notify the Owner promptly in writing of damage or defect and the extent of repair and/or adjustment required to bring the OFE to original specification. Service OFE only as directed by the Owner, under the arrangements of a separate contract or agreement.

3. Incorporate OFE equipment into the system as if provided new, exempting any warranty coverage. The Contractor shall not be responsible for the warranty of OFE equipment unless specifically covered under a separate contract or agreement.

4. The Contractor shall be responsible for the physical safety and care of any OFE equipment while in their possession. Any damage or destruction of OFE equipment while in the Contractor’s custody shall be the responsibility of the contractor to remedy without additional claim.

E. Governing Clause

1. For the sake of brevity these specifications omit phrases such as “Contractor shall furnish and install,” “unless otherwise noted or specified,” etc.; nevertheless, the requirements of the specifications are mandatory, and these phrases shall be inferred. The mention of materials and operations implies the Contractor shall furnish and install such materials and perform such operations to the overall standards set by the Contract Documents. Exceptions are noted herein or shown on the drawings.

2. In the event that a Consultant is not a participant in this project after award of contract, all references to “Consultant” in this document shall be replaced with “Owner.”

F. Questions

1. Submit questions about the Drawings and Specification to the Consultant in writing.

G. Related Requirements

1. None

1.02 REFERENCES

A. Abbreviations and Acronyms

1. CNIA: Casper/Natrona County International Airport

B. Definitions

1. A/V System: A set of specified individual components (audio, video, control, and networking equipment as well as associated hardware and wiring) designed and configured to operate and one comprehensive system for the conveyance of audio/video content to an audience. A/V Systems may include, but are not limited to, the following major items:
   a. Audio mixers, equalizers, amplifiers, program sources, digital recording devices, microphones and other signal processing equipment;
   b. Loudspeakers and loudspeaker mounting, aiming, rigging, and support hardware;
   c. Video switching, video over IP transmitters/receivers, video display equipment, video conferencing systems, cameras, and other video playback devices.
   d. Network equipment;
   e. Control equipment;
   f. Equipment racks, cabinetry, and furniture;
g. System accessories;
h. Cable, connectors, adapters, plates, panels, transformers, and other interface devices.

2. Owner: The designated responsible party with authority to make final decisions on contract and technical issues as well as provide final acceptance of the A/V Systems. May also include designated representatives and/or subordinates as part of a larger “Owner Team” such as End-users, Facility Managers, A/V Technology Managers, Building Committees, Purchasing Agents and/or Contract Representatives.
   a. Casper/Natrona County International Airport

3. Architect: The “Architect” referred to in this specification is the entity who has been hired to design and specify the physical environment the AV systems is to be installed within (e.g., the building, facility, room, and/or space). The architect is generally responsible for hiring and managing the various entities that constitute the design team (architects, engineers, consultants, etc.).
   a. MOA Architecture

4. Consultant: The “Consultant” referred to in this specification is the entity who has been hired to design and specify the AV System as well as work with other design team members and well as contractors/trades to ensure proper collaboration
   a. K2

5. Contractor: The “Contractor” referred to in this specification is the A/V Systems Contractor selected by the Owner, through competitive bidding or negotiation, to provide the AV systems described by this specification, and to whom a contract has been awarded to do so.

6. Masculine Pronoun: In all cases where a masculine pronoun is used within these specifications, the pronoun is used in the interest of simplicity of syntax, and the reference shall be interpreted as genderless.

C. Reference Standards

1. The workmanship and installation of the audio video systems and equipment shall adhere to industry best practices, AVIXA standards, and all national and local codes.

2. The following documents, or the versions closest in time prior to the release of this specification, shall form a part of this specification to the extent specified herein. Where the requirements of these documents conflict with the instructions herein, the requirements of this specification shall govern.
   b. Electronics Industry Association/Telecommunications Industry Association (EIA/TIA) Standards.
   c. International Telecommunications Union (ITU) Standards.
   d. Society of Motion Picture and Television Engineers (SMPTE) Standards.
   e. Audio Engineering Society (AES) Standards.
   f. American National Standards Institute (ANSI)
   g. Building Seismic Safety Council (B.S.S.C.)
D. Other Reference Standards


1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination

1. Coordinate work with Owner personnel involved in this project, Consultant representatives and employees/subcontractors employed of/by Owner, including electricians and the scheduled work of other trades.

2. Cooperate with all trades present on the project, so that lost time, work stoppages, interference, and work inefficiencies do not occur.

3. Assure labor "harmony" among personnel and subcontractors, and with other trades associated with construction, delivery, installation, and testing of the facility.

4. Failures in coordination shall not be a reason for additional payment to correct omissions or errors.

5. Coordinate the electrical and conduit requirements of this contract, and verify that all power, conduit, non-specialty boxes required for this contract is in the General/Electrical Contractor’s scope of work. If there is a discrepancy between this contract and the Electrician’s scope of work, notify the Owner and the Consultant, and request clarification or modification of the Contracts to achieve coordination.

   a. Any discrepancy does not relieve the A/V System Contractor from responsibility for a complete working system, and coordination with the electricians and representatives of the Owner in the course of his or her installation is required to achieve a correct conduit system.

   b. It is the Contractor’s responsibility to verify that all conduits, junction boxes, raceways, and back boxes will be of the proper size and type to meet the project requirements.

B. Pre-installation Meetings

1. Meet with the Owner on the site and reach a written understanding regarding project conditions outside the A/V Systems Contractor’s scope of work which will impact the timely completion of this contract.
2. Items that must be coordinated include a schedule of access to equipment room and other areas where access will be required; security of the equipment room; secure storage for equipment and tools on site; cleanliness of the equipment room including both trash and dust; HVAC for the equipment room; technical power in the equipment room and other required locations; conduit and junction box completion; any wire pulling needed for this contract but not provided by the A/V Systems Contractor; any and all job site conditions that may impact the timely completion of this contract or its conclusion in excellent condition; and any and all other work that must be provided by others that is required for the timely completion of this contract or its conclusion in excellent condition.

3. Develop an agreed timeline for all the above items, showing the last acceptable completion date for each item, and signed by the Owner and the representative of the A/V Systems Contractor.

4. The Electrical Contractor for the project shall be designated by the awarded General Contractor. The AV Contractor shall meet with the General Contractor and the Electrical Contractor and present them with a copy of the signed and approved timeline. Discuss the electrical issues on the timeline and make sure the time requirements are understood by the General Contractor, Electrical Contractor, and Owner.

5. Meet with any other contractor whose work will impact the performance of this contract, and coordinate as outlined above.

C. Sequencing
   1. As required, sequence work with the Owner and all trades present on the project.
   2. Notify the Owner and/or Owner’s Representative immediately of any issues of sequencing so that lost time, work stoppages, interference, and work inefficiencies do not occur.

D. Scheduling
   1. Coordinate and schedule all on-site activities with the Owner.
   2. A/V System Contractor shall work and complete all on-site tasks in accordance with the access to the site provided by the Owner.

1.04 SUBMITTALS

A. General
   1. Submit A/V System product information, shop drawings, and samples to the Consultant for review. Begin submittals not later than ten (10) days after the date of Contract execution; failure to comply with this requirement shall be cause for cancellation of the contract, on the basis the selected Contractor does not have the ability or intention to comply with the specifications or schedule. Submit product data binders and submittal drawing information in not more than three submittals. If any submittal drawings are rejected, correct and resubmit within five (5) working days.
   2. Obtain approval prior to ordering material or fabrication. Ordering, receipt, or assembly of any equipment before approval is done entirely at the risk of the Contractor, and any rework required is not a valid cause for delay to the project or additional cost to the Owner.

B. Product Data
   1. Product data submittals to be submitted for review according to general project requirements. The Contractor shall utilize the project information management system
(PIM). If hard copies are required, see specific submittal requirements below. The Contractor shall verify the project requirements before providing product data submittals for review.

2. Provide product data submittal as a single submittal for review.
   a. Provide product data submittal for Consultant review organized with logical and consistent formatting such as font choice, font size, margins, page headers and footers showing project, spec section, date, page numbering, etc.
   b. Provide title sheet with Project Name, Owner, Specification Section, Date of Submittal, AV Contractor contact information, and any other pertinent project information.
   c. Provide a table of contents (TOC) outlining major sections as noted below. Include operable bookmarks and page numbers for major sections.
   d. Provide clear section labels and page breaks for each major section such that it is clear when one section ends and another starts.
   e. Organize product data submittal into the following six (6) major sections.
   f. Section I
      1) Provide a complete bill of materials (BOM) in spreadsheet format of all major and minor products, hardware, and materials to be provided. Logically group according to specification format—as provided in appendix/appendices. Include any additional or ancillary items not shown in specification required for a complete and working system.
      2) See “Appendix Z: FORMATTING REQUIREMENTS FOR SUBMITTALS” for layout and formatting requirements.
   g. Section II
      1) Provide the manufacturer's product data sheet or specification sheet for all equipment and materials contained in this specification.
      2) Organize and present the manufacturers’ product data sheets as provided in Section One BOM order. Full line catalogs, short form catalogs, user manuals, web prints, product pictures with little or no technical data, and unreadable photocopies are not acceptable.
      3) Remove extraneous and/or blank pages with no useful information.
      4) Remove any repeated information in non-English languages.
      5) If no specification sheet is available, excerpts from larger manufacturer information documents are acceptable. Adhere to the guidelines outlined above. Keep information provided relevant to pertinent technical data only and as brief as possible.
   h. Section III
      1) Provide in spreadsheet format proposed project install cables and associated connectors. Provide the make, model, and the specific use conditions applicable to each cable type and associated connector. Provide ONLY the cables and connectors to be used for the project. “Typical” or “Standard” cable types and connectors shall be rejected and required for resubmission.
2) See “Appendix Z: FORMATTING REQUIREMENTS FOR SUBMITTALS” for layout and formatting requirements.

3) Provide the manufacturer's product literature for all cables and connectors.

4) Organize and present the manufacturers' product data sheets as provided in Section Three project cable types and connectors spreadsheet order. Full line catalogs, short form catalogs, user manuals, web prints, product pictures with little or no technical data, and unreadable photocopies are not acceptable.

5) Remove extraneous and/or blank pages with no useful information.

6) Remove any repeated information in non-English languages.

7) If no specification sheet is available, excerpts from larger manufacturer information documents are acceptable. Adhere to the guidelines outlined above. Keep information provided relevant to pertinent technical data only and as brief as possible.

8) Specifically note any proposed substitutions. **NOTE:** Submittal of proposed substitution does not guarantee acceptance by Consultant. All substitutions are subject to approval. Ordering, receipt, or installation of any cabling prior to approval is done entirely at the risk of the Contractor. Any rework, removable, and or re-installation required is not a valid cause for delay to the project or additional cost to the Owner.

i. Section IV

1) Provide the manufacturer's product literature for any products which are proposed substitutes to the equipment contained in this specification. Full line catalogs, short form catalogs, user manuals, product pictures with little or no technical data, and unreadable photocopies are not acceptable. **NOTE:** Submittal of proposed substitution does not guarantee acceptance by Consultant. All substitutions are subject to approval and ordering, receipt, or installation of any equipment prior to approval is done entirely at the risk of the Contractor. Any rework, removable, and or re-installation required is not a valid cause for delay to the project or additional cost to the Owner.

2) Remove extraneous and/or blank pages with no useful information.

3) Remove any repeated information in non-English languages.

4) If no specification sheet is available, excerpts from larger manufacturer documents are acceptable. Adhere to guidelines outlined above and keep information provided relevant to pertinent technical data only and as brief as possible.

j. Section V

1) Provide a list showing coordination of selected frequencies for all wireless microphone systems. When multiple frequency block is available from a manufacturer, note the manufacturer’s recommended block selection based on RF frequency coordination with TV channels and/or other local interference.

k. Section VI
1) Provide a schedule of finishes indicating proposed materials and color selections for all custom or exposed items subject to Owner’s selection and approval not explicitly noted in the BOM.

3. Electronic Submittal Requirements
   a. Submit one (1) portable document format (.PDF) file organized as outlined above.
   b. Provide operable bookmarks for major sections outlined above.

4. Hard Copy Submittal Requirements *(only if required)*
   a. Submit three (3) copies organized as outlined above.
   b. Utilize three-ring binders not exceeding 3" spine size, with clear vinyl pockets on cover and spine.
   c. Provide title sheets for cover and spine identifying the project and the system, room, or area covered by the submittal.
   d. Print title sheets in ink (pen plotter, inkjet or laser printer) on heavy paper sized to fill the entire pocket.
   e. Provide tabbed dividers for major sections outlined above.

C. Shop Drawings
   1. Shop drawings to be submitted for review according to general project requirements: project information management system (PIM) or hardcopy. AV Contractor to verify project requirements before providing shop drawings submittals for review.
   2. Minimum drawing sheet size: 24" x 36" (Arch D).
   3. Execute drawings at an appropriate scale, but not smaller than 1/8" = 1'-0", utilizing architectural scale factors exclusively.
   4. Title, number, and note the scale on each drawing.
   5. Submit one (1) electronic reproducible set (portable document format .PDF) and three (3) paper sets of drawings *(only paper sets IF REQUIRED).*
   6. Submittal drawings shall contain sufficient information to describe the work to be performed, or the item to be manufactured, and to thoroughly and completely guide installers, technicians, and manufacturers in the assembly of the system element.
   7. Drawings shall include but not necessarily be limited to the following:
      a. Cover Sheet
         1) Provide a cover sheet that includes general project information, drawing release, date, project engineer (and/or draftsperson), sheet index, and AV Contractor contact information.
      b. Legend and General Notes
         1) Provide a legend and general notes clearly showing symbols and other abbreviations used. Include details clearly showing and dimensioning cable preparation details for each cable and connector utilized in the system.
         2) Provide a complete labeling approach, including the proposed lettering/numbering scheme and data format that cable log will be supplied in. Include representative equipment labeling sizes, styles, and numbering.
(a) Follow AVIXA F501.01:2015 Cable Labeling for Audiovisual Systems standard.

3) Provide a schedule (table) clearly showing the installed cable types and connectors to be used for the project. Provide information related to the make, model, plenum/non-plenum, and field conditions under each cable is to be specifically used.

(a) Show ONLY the cables and connectors to be actually supplied and utilized on the project. Tables that are the “Typical” or “Standard” cable and connector types by the AV Contractor shall be rejected and shall be required for resubmission.

c. Floor Plans and Reflected Ceiling Plans

1) Provide architecturally scaled floor plans and reflected ceiling plans that show the location of all AV equipment, racks, consoles, millwork, etc. Include device names and pertinent installation details.

d. Sections and Elevations

1) Provide architecturally scaled sections and elevations that show the location of all AV equipment, racks, consoles, millwork, etc. Include device names and pertinent installation details.

2) Include detailed drawings of loudspeaker installation, showing the location, orientation, and support and aiming system for each case. Verify load ratings of all hanging components including attachment hardware.

3) Include detailed drawings of video equipment installation (e.g., projection screens, video projector mounting, LCD television mounting, etc.), showing the location, orientation, and support system for each case. Verify load ratings of all hanging/installation components including attachment hardware.

e. Wiring diagrams

1) Provide complete, detailed wiring diagrams for all systems, based on the contract drawings, but with the addition of:
   (a) Cable types, identification, and color codes
   (b) Cable numbers (as detailed above).
   (c) Details of connections, both at equipment and between equipment racks and furniture and wiring in the building
   (d) Application of connector models and types
   (e) Comply with AES, ANSI, IEC, and ISO recommendations and standards.
   (f) Schematic drawings of any custom circuitry or equipment modifications, including connector pinouts and component part lists.

f. Patch Panels and Custom Plates and Panels

1) Provide shop drawings of actual machine shop drawings since plates and panels are to be fabricated exactly as shown on the submittal drawings. If discrepancies are discovered by the Contractor due to errors or modification of a manufactured product, these must be called to the attention of the Consultant and propose their resolution on the Submittal Drawings.
2) Engraving details and requirements for patch panel and rack labels.

3) Finishes/Colors

g. Rack Elevations

1) Provide vertical elevation drawings for all equipment racks regardless of size showing all major equipment, shelves, drawers, vents, and other rack mount hardware.

2) Provide dimensions, wire routing, cabling, and support details, AC power outlet and ground buss locations, location of transformers, relays, accessories, etc.

h. Consoles, Enclosures, Tables, and Supports

1) Provide detailed construction drawings of cabinetwork and metalwork, including materials, finishes, adhesives, and fasteners.

8. References may be made in specification paragraphs to a requirement for submittal drawings for that particular item. Such references do not define the only items requiring submittal drawings.

9. Do not consider the Consultant's review of submittals to be exhaustive or complete in every detail. Approval of shop drawings and submittals indicates only the acceptance of the manufacturer, model, materials, general design or method of construction, and quality.

10. Requirements, arrangements, quantities, and installation must comply with the contract documents unless specifically approved to the contrary. Submittal approval does not relieve the Contractor of responsibility for errors in dimensions, details, sizes, fit, etc., or for coordinating items with actual building conditions and dimensions.

11. Submittals which, in the Consultant's opinion, are incomplete, deviate significantly from the requirements of the Contract Documents, or contain numerous errors, will be rejected and returned without review for rework and resubmittal.

D. Samples

1. Provide product samples as required herein or as requested by Consultant, Architect, or Owner.

2. Submit electronic copies of any custom programming including source code. Include printed copies of all control screens, wiring pages, etc.

E. Delegated Design Submittals

1. Include delegated design submittals for any systems or sub-systems that are not specifically designed by the A/V contractor but are required for review and approval. For example, this might include:

   a. Manufacturer designs for induction loop hearing assist systems

   b. Loudspeaker System or Room EASE (or other acoustic) models

   c. Structural engineering designs for loudspeaker hanging hardware

F. Test and Evaluation Reports

1. Shop Testing

   a. A/V equipment racks shall be populated, wired, and tested to the fullest extent possible in the Contractor's shop prior to shipping to the job site.
b. When applicable, measure, and record the DC resistance between the racks ground bus bar and the chassis of all rack-mounted components. Also measure and record the DC resistance between the rack ground bus bar and the signal common for all components.

2. Field Testing
   a. Before delivery of equipment to the job site, submit any test reports for all measurements specified under Shop Testing above.
   b. Before delivery to the job site, submit photographs depicting the quality of wiring and grounding within equipment racks.
   c. Immediately after installation, submit photographs showing cable entries and terminations within equipment racks, enclosures and pedestals at the job site.
   d. All loudspeakers and loudspeaker assemblies shall be tested by the Contractor in the Contractor’s shop before delivery to the site.
   e. Make all equipment including loudspeakers available for testing by the Consultant on the site before installation

G. Questions
   1. Submit questions about the Drawings and Specification to the Consultant in writing.

1.05 CLOSEOUT SUBMITTALS

A. Maintenance Contracts
   1. Provide in writing any maintenance contracts included in the project.

B. Operation and Maintenance Data
   1. Prepare Operation and Maintenance manuals as outlined below. Directly submit one (1) PDF copy of each manual to the Consultant for review at least ten days prior to acceptance testing. After review, make corrections and additions required by the Consultant. After approval, deliver two (2) approved printed copies of the System Reference Manual to the Owner unless otherwise directed by the General Project Requirements or the Owner or the Owner’s Representative.
   a. Assume the intended reader of the manual to be technically inexperienced and unfamiliar with the facility.
   b. Utilize three-ring binders not exceeding 3” spine size, with full-size clear vinyl pockets on front cover and spine.
   c. Provide title sheets for both cover and spine identifying the project and the system, room, or area covered by that manual; title sheets shall be printed in ink on heavy paper and fill the entire cover or spine pocket.
   d. Divide the manual into two or more binders
      1) Part I shall consist of the Systems Reference Manual
      2) Part II shall consist of the Maintenance Manual(s)
      3) Part III shall consist of the Warranty Reference
      4) The first section of each binder shall be a Table of Contents
5) Provide tabular dividers on heavy paper with permanent laser printed legends for the sections identified below.

6) Correct and update the System Reference and Maintenance Manuals, if necessary, according to the Consultant's instructions after acceptance testing.

7) Provide DVD or CD-ROM (unless otherwise requested by the Owner) copies of any training sessions for later review by the operators and maintenance staff.

2. System Reference Manual (Part I)
   a. System Description
      1) Provide a typed description of each system including key features and operational concepts (e.g., remote control features, switching or routing functions, patch points, mixing and linking capabilities).
   b. System Operation and Instructions
      1) Provide a "quick set-up" instructions (per space or system) oriented at inexperienced users under time pressure.
      2) Provide a "typical procedures" instructions (per space or system) for the operation of the equipment.
      3) Provide a "complete procedures" for the operation of the equipment as a system, organized by subsystem or activity.
   c. Equipment Settings
      1) Provide a list of the settings of all semi-fixed controls, as finalized after Acceptance Testing. When these settings are in a software format, include software files with settings saved on them. Indicate the name of the product that the file is associated with and all file names on a label physically attached to all software provided.
   d. As-Built Drawings
      1) Include corrected (as-built) wiring diagrams of each major subsystem, including plans showing locations and circuit numbers for all system outlets and receptacles, mounting and other pertinent details of the system installation, based on the contract drawings, at a reduced scale easy to handle but fully legible. Normal maximum drawing size: 24" x 36". Provide one additional full-size bound set separately, as well as one electronic set in portable document format (.PDF) format for Owner and Consultant.
      2) Provide an additional set of reduced-size drawings placed in a pocket folder attached to the equipment rack for convenient future reference.
   e. Manufacturers' Operation Manuals
      1) Provide manufacturer's instruction manuals for all items of equipment, incorporating manufacturer's warranty statements. Provide printed original manuals, not photocopies, unless more copies of a manual are required than the number of units in the total system. For custom circuits or modifications, provide a thorough description of the purpose, function, specifications, and operation.
   f. Other Data
1) Provide any other pertinent data generated during the project or required for future service.

3. Maintenance Manual (Part II)
   a. Contractor’s Warranty
      1) Include a clear statement of the terms and period of the Contractor's warranty; Contractor's service department phone and facsimile number(s) and hours; maintenance schedule; description of products recommended or provided for maintenance purposes; and instructions for the proper use of maintenance products.
   b. Equipment List
      1) Provide a comprehensive list of all equipment by subsystem, tabulating the manufacturer, model, serial number, physical location, and wiring diagram drawing number and code.
   c. Manufacturers’ service manuals
      1) Provide manufacturers’ service manuals for all major equipment items. For custom circuits or modifications, provide a thorough description of the purpose, function, specifications, and operation.
   d. Performance Test Reports
      1) Include a copy system startup test report generated meeting the requirements outlined in Section 3 of this Specification, and test results generated during Commissioning of the system.
   e. Maintenance Schedule
      1) Provide a recommended preventative maintenance schedule with reference to the applicable pages in the manufacturer’s maintenance manuals. Where inadequate information is provided by the manufacturer, provide the information necessary for proper maintenance.

4. Warranty Documentation (Part III)
   a. Contractor’s Warranty
      1) Include a clear statement of the terms and period of the Contractor's warranty; Contractor's service department phone and facsimile number(s) and hours; maintenance schedule; description of products recommended or provided for maintenance purposes; and instructions for the proper use of maintenance products.
   b. Manufacturers’ Warranty
      1) Provide a list of the various manufacturer’s warranties for all the major equipment.

C. Record Documentation
   1. Keep a complete set of documents - contract and approved submittal - on the job, note any changes made during installation.
2. Provide a corrected set of as-built shop drawings in PDF format showing the work as installed, with input and output levels noted, for review and inclusion in the Closeout Submittals.

D. Software

1. Provide a properly licensed working copy of the latest version of any and all contractor-provided software required to operate or configure the systems specified herein shall be a part of the system supplied. This includes, but is not limited to, all software, firmware and hardware required for configuration, adjustment, diagnosis and repair.

2. Software shall be fully documented, and that documentation shall be included.

3. The Owner shall retain ownership of all software. This includes both out of the box software and custom scripting and control software as well as the associated source code.

4. Software shall be included in its “installable” state on industry standard CD-ROM, USB flash drive, or another appropriate format. Back-up of the working software may be provided as an additional inclusion. Disk images are unacceptable.

E. Logins and Passwords

1. Provide any logins and password required for the operation, maintenance, or modification of the AV Systems. This includes, but is not limited to, both hardware as well as software.
   a. Audio DSP
   b. Control Systems
   c. Network Switches and Wireless Access Points
   d. Configuration and Maintenance Computers
   e. Touch Panel PIN numbers.
   f. Any other password protected equipment.

1.06 MAINTENANCE MATERIAL SUBMITTALS

A. Spare Parts

1. The specification may list extra quantities over and above those needed for the installation. Such extra quantities are intended as Owner’s on-site spares and are to be turned over to the owner during the training session. Spares may include fuses, lamps, power supplies, hard drives (pre-loaded with all software), rack screws, connectors, phoenix connectors, etc.

B. Keys

1. Submit in triplicate all keys required for access to, and operation of, the systems.

C. Tools

1. The specification may list tools that are to be provided and turned over to the owner during the training session. Tools may include crimpers (both ratchets and dies), adjustment tools, extraction tools, etc.
   a. Provide manufacturer’s storage case if applicable.

1.07 QUALITY ASSURANCE

A. Qualifications
1. The A/V system described in the Specification is a complex system requiring the services of a trained and experienced specialty contractor with the resources to carry out the project in a timely and professional manner.

2. A/V Contractor shall be a member of the AVIXA AV Provider of Excellence Program (APEx) or equivalent AV industry quality program.

3. A/V Integrator’s project team members shall be recognized by the AVIXA certification process, and the team shall possess certifications by percentage of team members.
   a. Engineers required CTS-D 30% or a minimum of one (1), CTS 70%
   b. Supervisors required CTS-I 30% or a minimum of one (1), CTS 70%
   c. Technicians and other installers CTS-I 10% or a minimum of one (1), CTS 40%, AVIXA Recognized AV Technologist 50%.
   d. No technical staff may be without at least the AVIXA Recognized AV technologist certificate or equivalent independent qualification
   e. Manufacturer’s certifications in the installation and maintenance of the A/V systems specified herein.

4. Unless specifically pre-qualified for the project (see Part 3.1), the A/V Contractor shall demonstrate previous experience in the engineering and installation of an Airport A/V systems for similar projects and provide the following information with their proposal.
   a. AV project team resumes.
   b. AV project team industry qualifications and (manufacturer’s) certificates.
   c. AV project team organizational chart
   d. Corporate AV industry membership certificates.
   e. Five (5) project references with telephone and e-mail contact information for past completed projects of a similar nature. This shall include both examples of previous work through photographs and example submittals.
   f. Sample shop drawings—schematic and layout
   g. Sample photographs from past projects including front and rear rack assemblies.
   h. Details of the A/V Contractor’s workshop(s).
   i. List of the A/V Contractor’s workshop tools and test equipment.

B. Continuity of Supervision

1. The Contractor shall maintain the same individual in charge of work for the full duration of the project unless illness, loss of personnel, or other circumstances beyond the control of the Contractor intervene.

C. Certifications

1. As required, all certifications shall be current, and the organization or individual(s) shall be in good standing with the certifying entity.

D. Regulatory Requirements.

1. Obtain all permits necessary for the execution of any work pertaining to the installation or operation of any system equipment by the Owner. Comply with applicable federal, state, and local labor and union regulations.
2. Execute all work in accordance with the National Electrical Code, the National Electrical Safety Code, the Life Safety Code, and all applicable federal, state, and local codes, laws, ordinances, regulations, and requirements including, but not limited to, those of OSHA, EEOC, ATBCB, ADA, ANSI, UL, and the FCC. If a conflict exists between the contract documents and any code or regulation and is reported to the Consultant sufficiently before bid opening, the Consultant will prepare the clarification required. Where a conflict is reported after the contract is awarded, propose a resolution of the conflict and, upon approval of the change, install the work.

E. Construction Observation

1. The failure of the Consultant or another representative of The Architect or Owner to condemn any defective work or material shall not release the Contractor from the obligation to at once tear out, remove, and replace the same at any time prior to final acceptance upon discovery of said defective work or material.

F. Safety

1. Site Safety and Personal Protection Equipment
   a. Contractor shall adhere to all site safety requirements as directed by the Owner, Owner’s Representative, Building or Site Supervisor including, but not limited to general project safety training and/or site-specific training for possible contact with chemical, radiological, physical, electrical, mechanical, or other workplace hazards.
   b. Contractor shall adhere to all PPE (personal protective equipment) requirements.
   c. These requirements shall include, but not be limited to, any personnel assigned to the project that may perform work onsite including project engineers, project managers, installers, programmers, and/or other technicians.
   d. Contractor shall keep all safety certifications in full force until all work is completed and accepted by the Owner.

2. Seismic Safety
   a. Observe mechanical and electrical support means of all installed equipment as required for the seismic hazard zone for this installation. Refer to Federal Emergency Management Agency (FEMA) Document 303: Recommended Provisions for Seismic Regulations for New Buildings and Other Structures. Also refer to any applicable local building codes.
   b. All equipment racks are to be anchored with suitable anchors to meet safety standards.
   c. Appropriate safety attachments as required for overhead mounting of devices.
   d. Shock and/or vibration isolation of equipment or fixtures as required.

3. Fiber Optic Cable Safety
   a. The following warnings shall be posted on the job site: WARNING: PERMANENT EYE DAMAGE CAN RESULT FROM LOOKING DIRECTLY INTO A LIGHT BEAM GENERATED BY AN LED OR LASER SOURCE OR INTO THE END OF A CABLE FIBER CONNECTED TO ONE OR THESE SOURCES. CAUTION: LIGHT GENERATED BY THESE SOURCES MAY NOT BE VISIBLE, YET REMAIN HAZARDOUS TO THE EYE. LOOK FOR WARNING LABELS ON SOURCE DEVICES.
b. Observe all warning signs on equipment and all written safety precautions in the instruction manual or equipment technical manual.

c. Always handle cable carefully to avoid personal injury. Care should be taken with individual fibers to prevent injury to the eyes or penetration of the fibers into the skin.

4. Asbestos Prohibition
   a. No Asbestos containing materials shall be used under this section. The contractor shall ensure that all materials incorporated in the project are Asbestos free unless specifically authorized in writing by the Owner.

1.08 DELIVERY, STORAGE, AND HANDLING

   A. Delivery and Acceptance Requirements
      1. Coordinate with Owner’s Representative for any equipment and materials to be delivered on site.
      2. All equipment shall be assembled in the Contractor's shop into equipment racks, furniture, or other assemblies, and fully wired and tested before delivery to the site.
      3. Do not ship, or cause to be shipped to the site, any material without first ensuring secure dust-free storage facilities are available, and HVAC system is operating.

   B. Storage and Handling Requirements
      1. Coordinate with Owner’s Representative for any equipment and materials to be stored on site.
      2. Store and protect products and material in accordance with common sense and the manufacturer's recommendations, regardless of location.
      3. As needed, provide for a secure storage location for any products and materials stored on site.

   C. Waste Management
      1. Coordinate with the Owner, Owner’s Representative, and/or Building Superintendent for the disposal of packaging as well as other debris and waste materials caused by the installation from the site to an approved common trash point or receptacle.
      2. Participate in any project construction and demolition waste management plans (LEED).
      3. In lieu of any specific project construction and demolition waste management plans, the Contractor is encouraged to develop and maintain an AV waste management plan that diverts equipment packaging and construction waste away from landfills and towards recycling facilities (plastic, cardboard, paper, wood, steel, etc.). The intent shall be to reduce construction and demolition waste disposed of in landfills and incineration facilities by recovering, reusing, and recycling materials.
      4. Keep work area neat and orderly and free from accumulation of waste materials.

1.09 FIELD CONDITIONS

   A. Ambient Conditions
      1. All locations where any portion of the equipment specified in this Section is installed must be temperature and humidity controlled, clean, and dust free.
      2. Conditions suitable for office work and equipment shall be acceptable.
3. Do not power up equipment unless you have a source of clean technical power, and the HVAC system is operating correctly.

4. Verify all conditions on the job site applicable to this work. Notify Owner and Consultant in writing of conflicts, discrepancies, or omissions promptly upon discovery.

5. Specific items will dissipate heat and must be provided with additional airflow and cooling. Make sure adequate HVAC is supplied to equipment spaces to remove the heat generated on a year-round basis.

6. The drawings diagrammatically show conduit, wiring, and arrangements of equipment fitting the space available without interference. If conditions exist at the job site which make it impossible or disadvantageous to install the work as shown, recommend solutions and/or submit drawings for approval showing how the work may be installed.

B. Existing Conditions

1. The system is designed to operate correctly given the current/designed physical and acoustic environment of the project site.

1.10 INSURANCE

A. Insure materials against theft, vandalism, damage due to the elements, fire, etc., to their full value. Materials and the flawless condition of materials shall remain the responsibility of the A/V System Contractor until acceptance of the system by the Owner.

B. Provide policies of insurance from reputable companies, in amounts sufficient to protect the Owner from any and all claims, actions, demands, losses, costs, judgments, or damages. The Contractor shall be required to adhere to the General Terms and Conditions and hold the project minimums as set forth by the contract documents. If not specifically called out, the following shall be the minimum amounts required:

1. Workman's Compensation and Liability for all personnel as required by law.

2. Motor Vehicle Liability, including coverage for owned, non-owned, and hired vehicles, with combined single limits of $1,000,000 per occurrence.

3. Commercial General Liability, including coverage for premises/operations and personal injury, with limits of $1,000,000 per occurrence.

C. Furnish certificate evidence of the insurance, and copies of policies, to the Owner prior to execution of a Contract.

D. Keep insurance in full force until all work is completed and accepted by the Owner. Insurance shall be modified or canceled only on written notice to the Owner, given thirty (30) days in advance, with replacement policies going immediately into effect.

1.11 WARRANTY AND BOND

A. Contractor’s Warranty

1. Labor and materials provided under this contract shall be warranted for one (1) year following the date of final acceptance to be free of defects and deficiencies, and to conform to the drawings and specifications as to kind, quality, function, and characteristics. Certain individual pieces of equipment may be covered for a longer period as provided in a specific manufacturer’s warranty. Rectify defects occurring in labor or materials within the Warranty period by replacement or repair without charge. Projection lamps are excluded from this Warranty unless damage or failure is the result of defective material or workmanship covered by Warranty, or work performed under warranty.
2. Within the warranty period, respond to service calls within twenty-four hours, and correct
the problem within forty-eight hours if at all possible.

B. Manufacturers’ Warranty
1. Register warranty in the Owner’s name for any product with a manufacturer’s warranty
stipulated in the Contract Documents.

C. Extended Correction Period
1. Three months after final acceptance, the Owner reserves the right to direct additional
minor changes to the control functions of the system software. Such changes shall be
made without additional cost to the Owner.

D. Bond Requirements
1. See general terms and conditions for both Bid and Performance bond requirements.

PART 2 PRODUCTS

2.01 OWNER FURNISHED PRODUCTS
A. New Products
1. None

B. Existing Products
1. Atlas/IED Paging System

2.02 EQUIPMENT
A. Description
1. See “APPENDIX A: PAGING SYSTEMS FUNCTIONAL DESCRIPTION”

B. Equipment
1. See “APPENDIX B: PAGING SYSTEMS EQUIPMENT LIST”

C. Substitute Equipment
1. Materials and products specified herein establish the overall performance level as well as
provide the physical appearance, component part quality, construction quality, and
background of proven reliability desired by the Owner and therefore define the “minimum
standards of quality” required for this project. Substitutions will generally not be
considered unless the materials or products have been discontinued.

2. If equipment or material other than that specified is proposed, furnish the Consultant a
written request including a detailed specification sheet and any samples or information
required for evaluation. Samples of specified equipment may be required as well as the
proposed substitute to facilitate comparison.

3. If required as a condition of accepting the proposed substitute, the Contractor shall
Warranty the quality of the substitute item. Contractor shall recognize function,
performance, appearance, size, utility of service, and accessory requirements are based
upon the model or product cited in the specifications, and that if a substitute product varies
in any respect and is approved, any additional cost incurred by such approval shall be
borne by the Contractor;

4. Approval of a substitute, if and when given, does not relieve the Contractor,
material/product supplier, or manufacturer of any responsibility whatsoever; but rather,
they jointly assume the responsibility the material/product installed will meet the functions, intent, and performance required by the contract drawings and specifications;

5. Delay in the delivery of any substitute product or material shall not be cause for change to the construction schedule or completion date.

6. The drawings and specifications are based on specific equipment, processes, and arrangements. At no additional cost to the Owner, furnish accessories, parts, and equipment, and perform all work necessary, for the proper functioning and fit of any approved substitute item to the purpose, arrangement, and intent originally indicated.

2.03 ACCESSORIES

A. Equipment lists may exclude minor components in the interest of conciseness and clarity. Where these components are integral to a functionally and aesthetically complete system, the Contractor shall without additional compensation provide them as outlined herein. This shall include manufacturer’s rack mount kits, power supplies, rack blank/vent panels, power distribution, cable management, etc.

PART 3 EXECUTION

3.01 INSTALLERS

A. General

1. All installation work shall be performed by experienced AV Contractors skilled and practiced in the proper techniques required for the activity involved.

B. Installer List

1. The following is a list of Contractors pre-approved to provide and install the systems listed herein:

   a. Ford Audio Video
      4230 Carson St
      Denver, CO 80239
      Tel. 720-374-2345
      Contact: Eric Paulson, Denver Division Manager

C. Substitution Limitations

1. Other Installers shall be considered acceptable provided they can demonstrate the qualifications outlined above. Refer to Part 1, Article “1.7 Quality Assurance”, Paragraph “A. Qualifications.”

2. Submittal of qualifications shall not mean acceptance or approval to bid on the systems defined herein.

3.02 EXAMINATION

A. Verification of Conditions

1. Verify all conditions on the job site applicable to this work. Notify Owner and Consultant in writing of conflicts, discrepancies, or omissions promptly upon discovery.

2. All locations where any portion of the equipment specified in this Section is installed must be temperature and humidity controlled, clean, and dust free.
3. If conditions exist at the job site which make it impossible or disadvantageous to install the work as shown, recommend solutions and/or submit drawings for approval showing how the work may be installed.

B. Pre-installation Testing
1. Install equipment into racks and furniture consoles and fully wire and test before delivery to the job site. If it is impractical to ship certain items installed in a console or rack, assemble, wire, and test in shop; then remove, ship separately, and reinstall at site.
2. Permanently mount all equipment; no equipment shall be installed loose or secured or suspended only by signal or power cables.
3. Panels or equipment mounted on rear rack rails shall not block clear access to the rear of any front mounted components or their wiring.
4. Mount racks on rubber isolation mat (Mason Industries Super W Pad or equal) when installing on steel or concrete floors, unless the rack is to be equipped with wheels (casters).

3.03 PREPARATION
A. Protection of In-Place Conditions
1. The contractor shall make reasonable accommodation to protect the surrounding areas and surfaces during the installation of the A/V Systems.
2. If the integrity of the surrounding areas and/or surfaces is in jeopardy, the A/V contractor shall notify the Owner or the Owner’s Representative, Building or Site Supervisor immediately and coordinate an appropriate action plan to protect the surrounding areas from damage.

B. Demolition/Removal
1. Coordinate with the Owner or the Owner’s Representative any requirements for the demolition/removable of existing A/V systems or equipment.
2. Coordinate the storage of any identified equipment to be removed and reused for the project.

3.04 INSTALLATION
A. General
1. Execute all work in accordance with the NEC, NESC, and with all local and state codes, ordinances, and regulations.
2. Coordinate work with all other trades to avoid causing delays in construction schedule. Expedite the delivery of equipment and materials and provide additional labor if required to meet the construction schedule.
3. Mount all equipment to be installed over public areas in a manner adequate to support the equipment loads with a minimum 10:1 safety factor or as specified by the Owner, using methods approved by the Owner. Awarded contractor to comply with all safety requirements. Requirements to be supplied to AV Contractor upon award.
4. Colors and finishes of all exposed and custom fabricated items and labels to blend in with the surroundings as approved by the Owner in the submittal process.
5. Install equipment in accordance with manufacturers' recommendations. Ensure that levels and impedances are properly matched between components. Verify that projector distances and lenses are appropriate for the corresponding screen sizes.

B. Mechanical

1. All equipment and enclosures shall be aligned, matched, true, plumb and square. All equipment, except portable equipment, shall be permanently attached and held firmly in place. Supports shall be designed to support loads with a safety factor of at least three, without sag or deflection.

2. Permanently mount all equipment; no equipment shall be installed loose or secured or suspended only by signal or power cables.

3. Panels or equipment mounted on rear rack rails shall not block clear access to the rear of any front mounted components or their wiring.

4. Mount racks on rubber isolation mat (Mason Industries Super W Pad or equal) when installing on steel or concrete floors, unless the rack is to be equipped with wheels (casters).

5. Provide ventilation adequate to keep the temperature within the rack(s) below 85 degrees F. Provide an approved low noise ventilation fan in each rack only if the temperature in the rack rises above 85 degrees when powered continuously for five hours.

6. Cover edges of cable pass-through holes in chassis, racks, boxes, etc., with rubber grommets or Brady GRNY nylon grommeting.

C. Wiring

1. Coordinate the final connection of power and ground wiring to junction box(es). Power and ground wiring shall be hardwired directly to power contactors and ground busses to ensure uninterrupted operation.

2. Execute wiring in strict adherence to the highest standards of acknowledged industry and professional practice.

3. Take whatever precautions are necessary to prevent and guard against electromagnetic and electrostatic hum. For permanently installed line level audio circuits, ground cable shields at the output of the source device and float at the input of the destination device. If RF interference is encountered, place an RC network between the floated shield and the input ground.

4. All wire, after being cut and stripped, shall have the wire strands twisted back to their original lay and terminated by approved soldered or mechanical means. No bare wire ends are acceptable. Cables with wire shields, braid or wound, must use all the wire conductors for shield termination, and not just a drain wire or some of the shield strands. Connections not following this requirement will be rejected. Foil shielded cables only provided with a drain wire must use the drain wire for shield termination. Fold shields or drain wires not connected back over the cable jacket and cover with heat shrinkable tubing; do not cut off unused shields or drain wires. Dress the shield or drain wires with Teflon tubing, and install heat shrinkable tubing over the junction of the fanout and outer jacket.

5. Exercise care in wiring; damage to cables or equipment will not be accepted. Isolate cables of different signal types or levels, and separate, organize, and route cabling to prevent crosstalk or feedback oscillation in any amplifier section. In all cases, separate
wiring for microphone signals, audio line level signals, loudspeakers, video, control, RF, and power into groups.

6. Rack Wiring. Contractor shall follow AVIXA F502.01:2018 “Rack Building for Audiovisual Systems” standard. Adhere to all cable management and signal separation recommendations/best practices. Run wiring vertically inside adequately sized plastic raceways, or employ an equivalent bundling and support system, to maintain a clear and organized appearance. Support all horizontal wiring using horizontal support bars as needed. Route AC cords directly to the side of the rack, under or over the equipment chassis, and then back to the power outlets, tying the excess cord only at the side of the rack. Organize cabling so that signal and AC cords are in the least possible proximity.

7. All wiring and connections shall be completely visible and labeled in the rack.

8. No splices shall exist in any length of cable run unless specifically shown on the contract drawings at a designated junction enclosure. All cables shall originate and terminate at active or passive devices. Where several devices are in close proximity, utilize approved housing-to-housing connectors and adapters; all such adapters shall be rotational.

9. Do not wire any cables with a polarity reversal between connectors, end for end, unless required by the manufacturer for operation. Connect all loudspeakers electrically in phase and of consistent polarity, using the same wire color code for loudspeaker wiring throughout the project. Note that different manufacturers employ differing color coding conventions for driver terminals. Wire all drivers - cone, compression, ribbon, or any other type - so that a positive voltage at the power amplifier ”+” terminal causes a positive acoustic pressure out of the driver/enclosure system.

10. For cables terminating at an interface or connection plate mounted on or in an enclosure, dress cables so as to allow removal of the plate from the enclosure and sufficient cable length for service or re-termination. In these circumstances, the plate shall set on the floor or freely swing clear.

11. Install cables without sharp bends or distortion. Where limited clearance prevents the manufacturer's recommended minimum bend radius from being observed, such as in junction boxes, provide a right angle or similar connector.

12. All expansion loops must be neat, and roughly the same size to provide for ease of servicing in the future.

13. In pulling cable, do not bend to less than the manufacturer's recommended radius. Employ temporary guides, sheaves, rollers, or other tools to prevent excessive tension or abrasion to the cable(s). Pull cable with tensions, tools, and lubricants recommended by the manufacturer.

14. Prepare television system semi-rigid cable in accordance with manufacturer's recommendations, with approved coring, cleaning, preparation and assembly tools. Do not score center conductor; utilize tubing cutters to trim the outer conductor. Completely deburr all conductors. Utilize approved center conductor cleaning tool; degrease the connector and cable prior to termination. Torque connectors to the manufacturer's recommended values.

15. All coaxial or triaxial video or RF connections to plates or panels in boxes, pedestals, racks or any similar location with limited clearance that would prevent that the associated cable manufacturer's minimum bend radius from being strictly observed shall be provided with the appropriate right angle or similar adapter as appropriate.
16. All cable installed under this specification which is to be terminated by others for “future” or Owner Furnished Equipment (OFE) in racks, shall be provided with ten (10) feet of slack when dressing to the location of future or OFE equipment. All cable installed under this specification which is to be terminated by others shall be provided with twenty (20) feet of slack when ending in a rack enclosure. All cable provided under this specifications, to be terminated by others, shall be provided with fifty (50) feet of slack when terminating in an equipment room without a clear point of demarcation, or in a group of racks where the destination is not known.

17. Fiber Optic Cables
   a. Consult Sumitomo document #SP-F01-001, Issue 4 for installation guidelines.
   b. All fiber splicing shall utilize the fusion splice method. The maximum allowable loss per fusion splice shall be 0.2 dB average.
   c. The bend radius shall be no less than manufacturer’s specifications.
   d. The total degrees of turn shall be no more than the manufacturer’s specifications.
   e. The pull force shall be no more than the manufacturer’s specifications.
   f. When each cable reel arrives from the manufacturer, it shall have a Factory Lot test report attached to it. Factory Lot test reports, for example, Belden Wire & Cable Company Fiber Tracking System, shall be copied to the owner and their representatives upon acceptance of the cable on the site.
   g. The use of the cable shall be tracked from the reel to each pull. Paperwork, in chart form, shall include the Reel Number, Code ID, and each conduit designator and description that includes cable from the specific reel.
   h. Splices, terminations, and any patching shall take place after the location has been declared “Dust Free” or “Clean.” Special care shall be taken to ensure the integrity of the fiber and connection(s) when these conditions cannot be met. Fiber found to be broken in the length of the run after the pull shall be deemed to be damaged during the installation process and replaced at the expense of the installer.

18. Network Wiring:
   a. Unless specifically called out for a connection, all data cabling is to be Unshielded Twisted Pair (UTP). The minimum acceptable performance rating for UTP and all associated connectors is Category 6 (CAT 6). All completed Links including all components making up a complete interconnection link between two Ethernet components shall be tested after installation and certified to meet or exceed CAT 6 Gigabit Ethernet performance requirements.
   b. Full test results for every complete Link, Permanent Link, and Patchcord must be made available in printed form as part of the Record Documentation before Acceptance Testing.
   c. No UTP cable may exceed 90 meters in length. All permanently installed UTP must be 4-pair solid wire and terminated according to the connector manufacturer’s instructions in outlets certified as meeting CAT 6 or better specifications.
   d. In no circumstances may solid wire UTP be terminated in RJ-45 plugs not certified by the manufacturer specifically for solid wire.
e. All UTP patch cords must be factory made and certified by their manufacturer as meeting at least CAT 6 performance. These patch cords must be made with 4 pair stranded wire. Unless otherwise noted, all patch cords must be provided with strain relief boots.

f. All UTP wiring shall follow the EIA/TIA 568B color code.

g. Under no circumstances may more than 1/2" of the pairs in a UTP be untwisted as terminated in a connector, nor may more than 1/2" of a pair be exposed past the end of the jacket of the UTP.

h. Interconnections between Ethernet switches may require that the patch cord at one end be a crossover cable. If the switches in question require a crossover cable for proper operation, supply the appropriately wired cable at one end. All crossover cables must be prominently marked indicating they are not normal straight-through cables.

i. All UTP cabling must be installed following industry standard minimum spacing requirements for specific electromagnetic interference sources as outlined in the NEC/NFPA 70 Article 800-52.

j. Ordinary plastic cable ties are not permitted on all UTP cabling. Plastic cable ties or anything else that can pinch the jacket of the UTP must be avoided. Use Velcro strap type ties as required.

k. UTP cables must never be combed out so neatly that they run parallel to each other. Such a practice can cause "alien crosstalk" between the cables that run next to each other. Instead let the UTP cables run with a loose and random lay.

l. UTP cables must never be bundled snugly together.

m. UTP cables installed in Conduit or other wire ways must never exceed 40% fill.

n. UTP cables must never have more than 25 lbs. (or the manufacturer's maximum recommended pull force if lower) of force applied while pulling into conduit or at any other time during installation.

o. UTP cables must never be bent sharper than a 1" radius (2" diameter) bend even if straightened out afterward.

D. Connections

1. Microphone, Audio line, video, time code, MIDI, RF, and digital signal or control wiring shall be continuous and unbroken from connector plate/chassis to chassis/patch panel, unless a terminal, connector, or other splice is explicitly shown on the contract drawings.

2. Make all joints and connections with rosin core solder or with mechanical connectors approved by the Consultant.

3. Make all solder connections with rosin core solder; employ temperature controlled soldering irons of wattage appropriate to the specific work involved. Soldering guns or unregulated irons are unacceptable.

4. Where spade lugs are used, crimp properly with ratchet type tool. Spade lugs shall be gold or nickel plated to match the receiving binding post or terminal.

5. Conventional non-ratcheting crimping tools are not acceptable.
6. Where terminal blocks are used, utilize Phoenix Contact MBK 2.5/E or MBK 5/E mounted on NS 35/7.5 DIN mounting rails or approved equal. All terminal blocks shall be fully exposed, labeled, and mounted on 1/2" birch veneer plywood board primed and painted two coats latex enamel or rack panels.

7. Make all connections with connectors specified herein. Employ XLR and BNC connectors wherever possible in preference to screw terminals, terminal strips, or phono connectors. All connectors employed shall be designed specifically for the cable in use.

8. Make connections to loudspeaker transformers with properly sized closed end connectors crimped with factory approved ratchet type tools, or terminal blocks.

9. All coaxial connectors shall be installed using the appropriate hexagonal die crimp tool or compression crimp tool that is correct for the combination of cable and connector. Non-ratcheting type crimping tools are not acceptable; the presence of such tools on the job site shall be interpreted as evidence of mechanical connections made incorrectly and shall provide sufficient grounds for rejection of all mechanical connections in the system.

10. "Electrical" adhesive backed tape is not acceptable for any purpose whatsoever. Adhesive cable tie anchors are only acceptable when employed for routing, not support; in any case, do not fasten anchors to any equipment chassis.

11. Do not employ connector adapters. Wire nut, "Scotchlock," or "Beanie" connectors are not acceptable for any purpose.

E. Labeling

1. Provide engraved plastic Lamicoid (or similar) identification labels at the front of all equipment mounted in racks. Install labels in a neat, plumb, square, and permanent manner. Mount labels on the equipment rack, not on the equipment, or on blank rack panels if so directed. Where the rack vertical frame has a slightly recessed mid-section, match label width to the recessed section width. Similarly, provide engraved labels at the rear only of equipment mounted in furniture consoles or frames. Equipment labels should have two items of information; the first identifying the equipment type, i.e., "POWER AMPLIFIER"; and the second showing the wiring diagram code, i.e., "AMP1-01".

2. Unless otherwise noted, engraving on plates, panels, and labels shall be 1/8" high, and the typeface, sans serif. Use white letter fill on dark panels or push-buttons, and black fill on stainless steel or brushed natural aluminum plates or light-colored push-buttons. Fill safety or operational warning labels orange.

3. Embossed labels are not acceptable for any purpose.

4. Label all cables except patch cords at both ends with self-laminating labels. Handwritten labels are not acceptable. Contractor shall follow AVIXA F501.01:2015 Cable Labeling for Audiovisual Systems standard. Locate labels within 2" of the connectors, consistent with regard to orientation, dress, and distance from the connector. For connections to in-room panels or floor boxes, label on cable should match panel engraving. For connections to portable equipment, label on cable should match device engraving.

5. Label each terminal strip with a unique identification code in addition to the numerical labels for each terminal (Phoenix Contact BN series). Show terminal strip codes on the system wiring diagrams.

3.05 RE-INSTALLATION
1. The process of acceptance testing may necessitate the moving or adjustment of certain components; perform without claim for additional payment.

### 3.06 FIELD QUALITY CONTROL

#### A. Field Tests and Inspections

1. Verify the following before beginning actual tests and adjustments on the system:
   a. All electronic devices are properly grounded.
   b. All powered devices have AC power from the proper circuit. All dedicated AC power circuits are properly wired, phased, and grounded.
   c. Insulation and shrink tubing are present where required.
   d. Dust, debris, solder splatter, etc. is removed.
   e. All cable is dressed, routed, and labeled; all connections are properly made and consistent with regard to polarity.

   a. Measure the DC resistance between the technical ground in any equipment rack or console and the main building ground. Resistance should be 0.15 ohms or less.
   b. Verify that the Owner where applicable has connected the technical ground to building ground at only one location with 4 AWG or larger wire.
   c. Measure the DC resistance between the signal ground at any connector plate and the conduit system.
   d. Identify and correct any problems if within the A/V System scope of work; notify the Owner if a problem is in a related area of work.
   e. The system shall be completely free of hum, parasitic oscillation, ground loops, RF interference, and any audible noise and distortion problems.

#### B. Non-Conforming Work

1. All identified non-conforming work shall be documented and remedied at no additional cost to the owner.

2. Any non-conforming work shall be subject to additional verification prior to acceptance.

### 3.07 SYSTEM START-UP

#### A. Audio System Tests

1. Perform the following tests and adjustments, supplying all test equipment required. Set for slow meter damping and A or Linear weighting as required. Document all tests and complete measurement results including wire number, date, test equipment used, operator, and test results. If any problems are detected in testing, correct the problem, and retest. Make corrections necessary to bring the system(s) into compliance with the specifications.
   a. Test all cables as installed for shorts between conductors or to building ground and opens.
   b. Measure the loop resistance of all loudspeaker cables.
c. Measure and record the impedance of each loudspeaker line circuit terminating at the equipment rack, with loudspeakers connected, over the entire frequency range from 20 Hz to 20 kHz.

d. Adjust the gain of each active device to provide an optimum signal-to-noise ratio and 18 to 20 dB headroom. Record input and output levels at each step in the signal chain.

e. Measure and record overall system hum and noise level of each mic or line amplifier with controls set so that -50 dBu microphone input or +4 dBu line level input would drive the system to full amplifier output. Terminate inputs with appropriately sized shielded resistors (150 ohms typical) for this test.

f. Measure and record system electrical frequency response for each input channel through power amplifier output with all filters and equalization bypassed in the DSP. Deviation shall not exceed ± .75dB within the range 20 Hz to 20 kHz.

g. Check system to assure freedom from oscillation or stray RF pickup. Check all inputs without signal and with 500 Hz sine wave driving system to full average output. Detect unwanted signals on an oscilloscope at rack termination and over single loudspeakers connected at the farthest distance from the rack for each loudspeaker line.

h. Apply a sinusoidal sweep signal to each loudspeaker system, sweeping from 50 to 5000 Hz at a level 10 dB below full amplifier output, and listen for rattles or objectionable noise. Correct any rattles or noise that is discovered.

i. Check the polarity of all loudspeakers with an electronic polarity checker, and by applying music program or pink noise signal to the system while walking through the transition areas of coverage from one loudspeaker to the next. The transition should be smooth with no apparent shift in source from one loudspeaker to the next.

j. Wireless Systems

1) Ensure that all wireless systems operate on different frequencies from each other and from any other transmitters in the area.

2) Coordinate frequency selection for compatibility with local RF environment.

B. Video System Tests

1. Verify performance of all video connecting cables, as specified herein. Continuity tests are not acceptable. Document all tests and complete measurement results including wire number, date, test equipment used, operator, and test results. If any problems are detected in testing, correct the problem, and retest. Replace any defective cable without claim prior to continuing tests.

2. Perform video signal parameter tests on individual items of equipment, and the work as a whole in accordance with EIA, SMPTE and AES Recommended Practices and other recognized standards as listed under REFERENCES.

a. Projection Systems Performance

1) Verify optical performance of projection devices to ANSI Standards using standard test signals connected directly to the device under adjustment.

2) Set devices level and true prior to adjustment, and mark positions for future reference.
3) Complete device’s optical adjustments for focus, centering, geometry and registration prior to applying any electronic corrections.

4) Do not under any circumstances apply corrections at signal sources to compensate for errors in device alignment or adjustment, or timing errors in source material.

5) Set brightness and contrast using reference test signals connected directly to the device. Adjust grayscale and grayscale tracking using ramp or stair step test signals. Set overall brightness and contrast with pluge and white flag signal.

6) Reconnect the projection devices to the system as a whole and verify performance of completed installations. Check that registration has not been affected by timing errors occurring elsewhere on all sources. Verify that source signal levels are consistent and match the reference levels set by the standard test signals. Correct any deficiencies noted.

7) Record lamp operating hours at the conclusion of adjustments.

b. Video System Tests

1) Test and document all links for compliance with SMPTE standards.

2) Verify performance of all video cables to SMPTE digital video standards using a test signal (Color Bars) connected directly to the device under adjustment.

   (a) Use professional level 0.800 volt peak-to-peak digital video test source with digital test signals. Recommended Tektronix SPG700 with OPT SDI (provides 3G/HD/SD-SDI signal outputs).

   (b) Use professional waveform monitor with physical layer test abilities. Recommended Tektronix WFM2300 with Option 3G (provides 3G HD-SDI signal inputs).

3) Perform Eye-pattern Testing

   (a) Verify cable length and cable loss. Compare measured cable loss to distance and manufacturer’s stated performance of the entire video link (cable and connector).

   (b) Verify signal amplitude, risetime, and overshoot.

   (c) Eye-pattern shall be open (or equalized open) and symmetrical.

   (d) Observe any overshoot and undershoots on the eye display indicating improper termination

4) SMPTE Digital Video Performance Standards

   (a) Analog NTSC Video: Test all links to SMPTE 259M standard.

   (b) SD-SDI (SMPTE 259M): 30 dB loss at 1/2 the data clock frequency (135 MHz)

   (c) HD-SDI/3G HD-SDI (SMPTE 292M/SMPTE 424M): 20 dB loss at 1/2 the data clock frequency (743 MHz/1.485 GHz).

c. CATV System Tests

1) Check all paths and outlets for appropriate compliance with the Performance Standards. Measure levels at all feeder termination points. Compare actual
values to design calculations and investigate any difference of more than 2 dB, rectify or justify these discrepancies to the satisfaction of the Owner. Document all tests and complete measurement results including wire number, date, test equipment used, operator, and test results. If any problems are detected in testing, correct the problem, and retest.

2) Television Distribution System amplitude standards:
   (a) Minimum visual sync-tip level: +3 dBmV
   (b) Maximum visual sync-tip level: +10 dBmV

3) CATV Cable Testing: Each Trunk Cable line shall be inspected for proper termination:
   (a) Using a standard TV receiver connected to each outlet, observe picture quality. No visible components of cross modulation (windshield wiper effect), ghosting, noise, or beat interference shall appear on the screen of the receiver tuned to any normal signal.
   (b) Carrier-to-noise test shall employ an approved field strength meter. Measurements shall be made at the termination of each Trunk Cable and system extremity. With the normal levels in the system, the field strength meter shall be tuned to the picture carrier of each channel in turn, and the meter reading noted. Tune the field strength meter to an unused portion of the spectrum within the passband, read the level of remaining noise in the absence of the signal and algebraically add the meter bandwidth correction factor. Record the difference between the two readings. Provide calculations or the manufacturer's data concerning the bandwidth correction factor.
   (c) System flatness, both forward and reverse, test shall employ an approved high-level sweep transmitter receiver pair. Sweep measurements shall be taken at the termination of every branch line termination in the system. Where possible, record sweep results by photographic or computer data logging means.

C. Fiber Optic Tests
   1. An OTDR shall be used to check each strand for:
      a. Loss per Unit Length: in dB.
      b. Splice and Connector Evaluation.
      c. Possible Fault Location.
   2. Test results from the OTDR shall be bound and copied to the owner and their representatives. A strand-per-data file index shall be included.
   3. Diligence shall be employed to produce efficient testing: i.e., connectors shall be checked with a microscope to determine whether a bad test run is a bad connector, bad termination, dirt, or a connector needing polishing.
   4. Connectors shall remain capped or otherwise protected, when not in use.

D. Network Tests
1. Check all paths and outlets for appropriate compliance with the Performance Standards. Document all tests and complete measurement results including wire number, date, test equipment used, operator, and test results. If any problems are detected in testing, correct the problem, and retest.

2. Certify all data cables to Category 6 (Draft 9a) or better using a tester capable of 350 MHz measurements such as Fluke DSP-4300, Agilent WireScope 350 or equivalent.

E. Report

1. Upon completion of the initial tests and adjustments, submit a written report of tests to the Consultant along with all documents, diagrams, and record drawings required herein. The Report shall include the date of each test, pertinent conditions such as control settings, etc., test circuit, and test equipment employed. In addition, submit written notification that the installation has been completed in accordance with the requirements of the Contract Documents, and is ready for acceptance testing.

3.08 COMMISSIONING

A. Provide the following test equipment on site and available to the Consultant during commissioning. Assure scaffolding or other temporary access equipment is in place if needed for inspection.

1. Tools, including screwdrivers, pliers, cutters, wire strippers, nut drivers, ratchet crimpers, heat gun, controlled temperature soldering unit, ladders, flashlights, measuring tapes, electric drills, long and short precision levels, etc.

2. Sound Pressure Level Meter. The meter shall meet ANSI S1.4 1971 Type 1 standards, with an octave band filter set and A, C, and Linear weighting filters. Provide stand for Type 1 microphone, and cables and interfaces to allow it to be used with the sound level meter, time windowed acoustical measurement system, or STI measurement device.


4. Sine Wave Generator. Output: +4 dBu, 5 Hz to 50,000 Hz with less than 0.03 % THD into any load.

5. Pink Noise Source. Equal energy per octave bandwidth over the band 20 - 20,000 Hz, ±1 dB (long-term average) at 0 dBu output. Stability: ±2 dB per day.

6. Multimeter. Measurement range, DC to 100,000 Hz, true RMS reading, 100 mV to 300 V, 10 ma to 10A, direct dB reading, frequency counter. Acceptable: Fluke 8060A or equal.


8. Programmable Video and Audio Test Generator with SDI/HD-SDI Output.
   a. SDI/HD-SDI, RGBHV, component video, S-video, and composite video output.
   b. Video test patterns including multiple crosshatch patterns, color bars, PLUGE, crop patterns, geometry, grayscale, and alternating pixel patterns, as well as flat field, window, checkerboard, hum bar, and Patented CTF Contrast Transfer Function patterns with adjustable levels.
   c. Selectable output rates, including high-resolution computer-video, HDTV, and NTSC/PAL video.
d. Audio test signals including sine waves, square waves, pink noise, white noise, polarity, frequency sweeps, and sine wave bursts with selectable frequencies and output levels.

e. Acceptable: Extron VTG 400D or equal.

9. Programmable Video and Audio Test Generator with DVI-D/HDMI Output
   a. DVI, RGBHV, component video, S-video, and composite video output.
   b. Displays native resolution of the DVI device when new EDID data is received.
   c. Video test patterns including multiple crosshatch patterns, color bars, PLUGE, crop patterns, geometry, grayscale, and alternating pixel patterns, as well as flat field, window, checkerboard, hum bar, and Patented CTF Contrast Transfer Function patterns with adjustable levels.
   d. Selectable output rates, including high-resolution computer-video, HDTV, and NTSC/PAL video.
   e. Audio test signals including sine waves, square waves, pink noise, white noise, polarity, frequency sweeps, and sine wave bursts with selectable frequencies and output levels.
   f. Acceptable: Extron VTG 400DVI or equal.

10. Portable Video and Audio Generator and HDMI Analyzer.
   a. HDMI Tx/Rx enabled testing of HDMI sink/source devices up to 300MHz.
   b. Test analog RGB video for PCs.
   c. HDMI 2.0 4:2:0 Testing. Generator patterns with 4:2:0 pixel encoding with 4K formats at 60Hz.
   d. HDCP Verification. Show HDCP test on the sink. Show each of the key steps in authentication.
   e. EDID Verification. Read sink EDID in human text, run partial EDID compliance test.
   f. Aux Channel Monitoring. View hot plug events, EDID exchange, HDCP transactions and CEC message exchange with sink.
   g. Status bar showing HDMI Out status.
   h. Cable & Link Test (loopback).
   i. 7” color touch screen.

11. Adapter and test lead kit to allow any of the above to be connected to any circuit or connector in the system.

12. Wire number machine as used to produce all the wire numbers for the project.

B. Have on site during acceptance testing all parts and components that may be required to make system repairs and minor modifications to bring the system in the Consultant’s opinion into compliance with the Specification. At a minimum these parts shall include:

1. All types of connectors used in the system. Plus, straight and right angle XLR 3, 4, and 5 pin connectors of both sexes, straight and right angle ¼” phone 3 conductor connectors of
both sexes, RCA connectors of both sexes, “F” connectors, and BNC connectors, even if not used in the system.

2. All types of wire used in the system.

3. All types of hardware used in the system, plus an assorted hardware kit.

4. All types of fuses used by equipment in the system.

C. Commissioning will include the operation of each major system and any other components deemed necessary. The contractor will assist in this testing and provide the test equipment specified herein. Contractor shall provide at least one technician available for the entire commissioning period, at any time of the day, to assist in tests, adjustments, and final modifications. Furnish all labor, tools, and material required to make any necessary repairs, corrections, or adjustments.

D. In the event the need for further adjustment or work becomes evident during acceptance testing, the Contractor will continue his work with a full labor complement until the system is acceptable, at no addition to the contract price. If approval is delayed because of defective equipment, or failure of equipment or installation to meet the requirements of these specifications, the Contractor will pay for additional time and expenses of the Consultant at the Consultant’s standard rate in effect at that time, during an extension of the acceptance testing period.

3.09 CLEANING

A. Remove all unnecessary tools and equipment, unused materials, packing materials, and debris from each area where Work has been completed unless designated for storage.

B. Clean all areas around system equipment and be sure that the inside of each equipment rack is free of wire stripping and other debris.

3.10 CLOSEOUT ACTIVITIES

A. Demonstration

1. Upon completion of the Work, the Owner may elect to verify test data as part of the acceptance procedure. Provide personnel and equipment, at the convenience of the Owner, to reasonably demonstrate system performance and to assist with such tests without additional cost to the Owner.

B. Training

1. Provide eight (8) hours instruction to Owner designated personnel on the use and operation of the system. This training must be provided in accordance with a schedule acceptable to the Owner. The instructor should be fully knowledgeable and qualified in system operation. The System Reference Manuals should be complete, approved, and on-site at the time of this instruction.

C. First Use

1. The A/V Contractor shall provide a person familiar with the system to be present at the first formal use of the system.

3.11 PROTECTION

A. The contractor shall make reasonable accommodation to protect the A/V equipment and completed work after installation, but prior to acceptance by the Owner.
B. When the integrity of the installation is in jeopardy, the A/V contractor shall notify the Owner or the Owner’s Representative, Building or Site Supervisor immediately.

C. Protection methods shall include, but not be limited to, the wrapping or “bagging” (in plastic) and/or the temporary removal of major equipment, wiring, and portable equipment.

3.12 ATTACHMENTS

A. None

END OF SECTION
APPENDIX A: PAGING SYSTEMS FUNCTIONAL DESCRIPTION

1.01 BASE BID - AUDIO PAGING SYSTEMS

A. System Functionality for Audio Paging Systems:
   1. Zones
      a. New Holding Room/Gates (including restrooms)
   2. Store and Forward Paging
   3. Ambient Noise Sensing/Volume Adjust
   4. Prerecorded Messages by Paging Zone
   5. Background Music
   6. General Notes
      a. Expansion of existing Atlas/IED paging system.
      b. Additional components NFPA compliance for intelligibility and UL were applicable.
      c. Existing headend located in 1st Floor electrical closet.
      d. Existing remote rack room located in 1ST floor Holdroom Electrical Room.

B. System Equipment
   1. 4-Button Wall-Mount Handheld Paging Microphones Locations
      a. Existing Holdroom Gate #3 (Qty 1)
      b. New Holdroom Gate #5 (Qty 1)
      c. New paging stations come with 3-year software license and updates. After 3-years, continuing software licensing and support is additional yearly fee.
   2. New Ceiling Loudspeakers
      a. UL listed 3” & 4” ceiling speakers with integrated back cans (size TBD by location)
      b. UL listed 6.5” pendant mount loudspeakers
      c. UL listed 4” shallow back can ceiling mount loudspeakers.
   3. New Ambient Noise Sensor
   4. New wiring, cabling, connectors, etc.

END OF APPENDIX A
# APPENDIX B: PAGING SYSTEMS EQUIPMENT LIST

<table>
<thead>
<tr>
<th>Description</th>
<th>Make</th>
<th>Model</th>
<th>Part Number</th>
<th>Device ID</th>
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<td>END OF LINE TESTING MODULE (FOR AMPLIFIER ZONES)</td>
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<td>IPCSD4</td>
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Hardware, Racks, and Materials
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<td>MISCELLANEOUS MATERIALS (CABLE, CONNECTORS, ETC)</td>
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END OF APPENDIX B
## APPENDIX Z: FORMATTING REQUIREMENTS FOR SUBMITTALS

**Bill of Materials Formatting Example**

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<thead>
<tr>
<th>Description</th>
<th>Manufacturer</th>
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*Add Additional Sections or Subsystems as Needed or Provide Individual BOM per Space*

---

**SECTION OF APPENDIX NAME**

**Client: Project Name**

*Section, System, or Room Name: Bill of Materials*

**MM/DD/YYYY**

**Bill of Materials**

**PAGE # OF #**
## Project Cable Types and Connectors Formatting Example

### Client: Project Name
- **Section, System, or Room Name:** Project Installation Cable Types and Connectors
- **WA20/XXYY**

### Project Installation Cables

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<th>Cable Type</th>
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<td>22/2 Speaker Audio Cable</td>
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<tr>
<td>M</td>
<td>22/2 Shock Cable</td>
<td>Interlink</td>
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<td>V1</td>
<td>22/2 Digital Video Cable</td>
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<td>18/2 Landscape Cable</td>
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### Client For All Cable Types Listed

### Project Installation Connectors

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### Client For All Connectors Listed — Including Types or Custom Colors and Options

---

END OF APPENDIX Z
ITEM P-101 PREPARATION/REMOVAL
OF EXISTING PAVEMENTS

DESCRIPTION

101-1.1 This item shall consist of preparation of existing pavement surfaces for overlay, surface treatments, removal of existing pavement, and other miscellaneous items. The work shall be accomplished in accordance with these specifications and the applicable plans.

EQUIPMENT AND MATERIALS

101-2.1 All equipment and materials shall be specified here and in the following paragraphs or approved by the Resident Project Representative (RPR). The equipment shall not cause damage to the pavement to remain in place.

CONSTRUCTION

101-3.1 REMOVAL OF EXISTING PAVEMENT.

The Contractor’s removal operation shall be controlled to not damage adjacent pavement structure, and base material, cables, utility ducts, pipelines, or drainage structures which are to remain under the pavement.

a. Concrete pavement removal. Full depth saw cuts shall be made perpendicular to the slab surface. The Contractor shall saw through the full depth of the slab including any dowels at the joint, removing the pavement and installing new dowels as shown on the plans and per the specifications. Where the perimeter of the removal limits is not located on the joint and there are no dowels present, the perimeter shall be saw cut the full depth of the pavement. The pavement inside the saw cut shall be removed by methods which will not cause distress in the pavement which is to remain in place. Waste material shall be disposed of offsite. Concrete slabs that are damaged by under breaking shall be repaired or removed and replaced as directed by the RPR.

The edge of existing concrete pavement against which new pavement abuts shall be protected from damage at all times. Spall and underbreak repair shall be in accordance with the plans. Any underlaying material that is to remain in place, shall be recompacted and/or replaced as shown on the plans. Adjacent areas damaged during repair shall be repaired or replaced at the Contractor’s expense.

b. Asphalt pavement removal. Asphalt pavement to be removed shall be cut to the full depth of the asphalt pavement around the perimeter of the area to be removed and disposed of offsite.

c. Repair or removal of Base, Subbase, and/or Subgrade. All failed material including surface, base course, subbase course, and subgrade shall be removed and repaired as shown on the plans or as directed by the RPR. Materials and methods of construction shall comply with the applicable sections of these specifications. Any damage caused by Contractor’s removal process shall be repaired at the Contractor’s expense.

101-3.2 PREPARATION OF JOINTS AND CRACKS PRIOR TO OVERLAY/SURFACE TREATMENT. Not used on this project.
101-3.3 REMOVAL OF FOREIGN SUBSTANCES/CONTAMINATES PRIOR TO OVERLAY, SEAL-COAT AND REMARKING. Not used on this project

101-3.4 CONCRETE SPALL OR FAILED ASPHALTIC CONCRETE PAVEMENT REPAIR. Not used on this project

101-3.5 COLD MILLING. Not used on this project

101-3.6. PREPARATION OF ASPHALT PAVEMENT SURFACES PRIOR TO SURFACE TREATMENT. Not used on this project

101-3.7 MAINTENANCE. The Contractor shall perform all maintenance work necessary to keep the pavement in a satisfactory condition until the full section is complete and accepted by the RPR. The surface shall be kept clean and free from foreign material. The pavement shall be properly drained at all times. If cleaning is necessary or if the pavement becomes disturbed, any work repairs necessary shall be performed at the Contractor’s expense.

101-3.8 PREPARATION OF JOINTS IN RIGID PAVEMENT PRIOR TO RESEALING. Prior to application of sealant material, clean and dry the joints of all scale, dirt, dust, old sealant, curing compound, moisture and other foreign matter. The Contractor shall demonstrate, in the presence of the RPR, that the method used cleans the joint and does not damage the joint.

101-3.8.1 REMOVAL OF EXISTING JOINT SEALANT. All existing joint sealants will be removed by plowing or use of hand tools. Any remaining sealant and or debris will be removed by use of wire brushes or other tools as necessary. Resaw joints removing no more than 1/16 inch (2 mm) from each joint face. Immediately after sawing, flush out joint with water and other tools as necessary to completely remove the slurry.

101-3.8.2 CLEANING PRIOR TO SEALING. Immediately before sealing, joints shall be cleaned by removing any remaining laitance and other foreign material. Allow sufficient time to dry out joints prior to sealing. Joint surfaces will be surface-dry prior to installation of sealant.

101-3.8.3 JOINT SEALANT. Joint material and installation will be in accordance with Item P-605.

101-3.9 PREPARATION OF CRACKS IN FLEXIBLE PAVEMENT PRIOR TO SEALING. Prior to application of sealant material, clean and dry the joints of all scale, dirt, dust, old sealant, curing compound, moisture and other foreign matter. The Contractor shall demonstrate, in the presence of the RPR, that the method used cleans the cracks and does not damage the pavement.

101-3.9.1 PREPARATION OF CRACK. Widen crack with router by removing a minimum of 1/16 inch (2 mm) from each side of crack. Immediately before sealing, cracks will be blown out with a hot air lance combined with oil and water-free compressed air.

101-3.9.2 REMOVAL OF EXISTING CRACK SEALANT. Existing sealants will be removed by routing. Following routing, any remaining debris will be removed by use of a hot lance combined with oil and water-free compressed air.

101-3.9.3 CRACK SEALANT. Crack sealant material and installation will be in accordance with Item P-605.

101-3.9.4 REMOVAL OF PIPE AND OTHER BURIED STRUCTURES.


b. Removal of Inlets/Manholes. Not used.
METHOD OF MEASUREMENT

101-4.1 PAVEMENT REMOVAL. The unit of measurement for pavement removal shall be the number of square yards (square meters) removed by the Contractor. Any pavement removed outside the limits of removal because the pavement was damaged by negligence on the part of the Contractor shall not be included in the measurement for payment. No direct measurement or payment shall be made for saw cutting. Saw cutting shall be incidental to pavement removal. Dowel bar installation shall be incidental to pavement removal.

101-4.2 JOINT AND CRACK REPAIR. The unit of measurement for joint and crack repair shall be the linear foot (meter) of joint.

101-4.3 SPALLED AND FAILED ASPHALT PAVEMENT REPAIR. Not used.

101-4.4 CONCRETE SPALL REPAIR. The unit of measure for concrete spall repair shall be the number of square feet (square meter). The location and average depth of the patch shall be determined and agreed upon by the RPR and the Contractor.

101-4.5 COLD MILLING. Not used.

101-4.6 REMOVAL OF PIPE AND OTHER BURIED STRUCTURES. Not used.

BASIS OF PAYMENT

101-5.1 PAYMENT. Payment shall be made at contract unit price for the unit of measurement as specified above. This price shall be full compensation for furnishing all materials and for all preparation, hauling, and placing of the material and for all labor, equipment, tools, and incidentals necessary to complete this item.

Payment will be incidental to the project bid.

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

Advisory Circulars (AC)

ASTM International (ASTM)
ASTM D6690 Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements

**END OF ITEM P-101**
ITEM P-152 EXCAVATION, SUBGRADE, AND EMBANKMENT

DESCRIPTION

152-1.1 This item covers excavation, disposal, placement, and compaction of all materials within the limits of the work required to construct safety areas, runways, taxiways, aprons, and intermediate areas as well as other areas for drainage, building construction, parking, or other purposes in accordance with these specifications and in conformity to the dimensions and typical sections shown on the plans.

152-1.2 CLASSIFICATION. All material excavated shall be classified as defined below:

a. Unclassified excavation. Unclassified excavation shall be measured from the bottom of any pavement sections designated for removal under Item P-101 to the top of the subgrade as necessary to construct the typical sections to the lines and grades as shown on the plans. Unclassified excavation shall consist of the excavation and disposal of all material, regardless of its nature, which is not otherwise classified and paid for under one of the following items:

b. Over excavation. Over excavation shall include all work to remove, replace, blend, and recompact materials from the areas under pavement structures that are deemed by the Engineer to be unsuitable to support pavement subgrades or foundations. Once subgrade preparation operations have removed the required depth of subgrade material, over excavation will include the removal and replacement of unsuitable materials to provide a uniform blend under subgrade material on which pavement and structural foundations are to be placed. Depth of over excavation shall be as shown on the plans or as directed by the engineer. Recompacted materials shall meet the compaction and moisture content requirements of section 152-2.8 Formation of Embankments. Over excavation may consist of importing pit-run material on an as needed basis for stabilization purposes. The pit-run material shall be obtained at an off-site source of the Contractor’s choice and location.

c. Subgrade Preparation. This item covers the preparation of the underlying subgrade directly below and prior to placement of any new subbase or base course layer. Any necessary excavation required so that the specified thickness of subgrade can be processed and compacted is included in this item. This area shall meet the compaction requirements of section 152-2.12.

152-1.3 UNSUITABLE EXCAVATION. Unsuitable material shall be disposed in designated waste areas as shown on the plans. Materials containing vegetable or organic matter, such as muck, peat, organic silt, or sod shall be considered unsuitable for use in embankment construction. Material suitable for topsoil may be used on the embankment slope when approved by the RPR.

CONSTRUCTION METHODS

152-2.1 GENERAL. Before beginning excavation, grading, and embankment operations in any area, the area shall be cleared or cleared and grubbed as required.

The suitability of material to be placed in embankments shall be subject to approval by the RPR. All unsuitable material shall be disposed of in waste areas as shown on the plans. All waste areas shall be graded to allow positive drainage of the area and adjacent areas. The surface elevation of waste areas shall be specified on the plans or approved by the RPR.

When the Contractor’s excavating operations encounter artifacts of historical or archaeological significance, the operations shall be temporarily discontinued and the RPR notified per Section 70, paragraph 70-20. At the direction of the RPR, the Contractor shall excavate the site in such a manner as...
to preserve the artifacts encountered and allow for their removal. Such excavation will be paid for as extra work.

Areas outside the limits of the pavement areas where the top layer of soil has become compacted by hauling or other Contractor activities shall be scarified and disked to a depth of 4 inches (100 mm), to loosen and pulverize the soil. Stones or rock fragments larger than 4 inches (100 mm) in their greatest dimension will not be permitted in the top 6 inches (150 mm) of the subgrade.

If it is necessary to interrupt existing surface drainage, sewers or under-drainage, conduits, utilities, or similar underground structures, the Contractor shall be responsible for and shall take all necessary precautions to preserve them or provide temporary services. When such facilities are encountered, the Contractor shall notify the RPR, who shall arrange for their removal if necessary. The Contractor, at their own expense, shall satisfactorily repair or pay the cost of all damage to such facilities or structures that may result from any of the Contractor's operations during the period of the contract.

   a. **Blasting.** Blasting shall not be allowed

**152-2.2 EXCAVATION.** No excavation shall be started until the work has been staked out by the Contractor and the RPR has obtained current elevations and measurements of the ground surface from the contractor's survey in a complete and usable electronic format approved by the RPR. The Contractor and RPR shall agree that the original ground lines shown on the original topographic mapping are accurate, or agree to any adjustments made to the original ground lines.

Digital terrain model (DTM) files of the existing surfaces, finished surfaces and other various surfaces were used to develop the design plans.

Volumetric quantities were calculated using design cross sections which were created for this project using the DTM files of the applicable design surfaces and generating End Area Volume Reports. Paper copies of design cross sections and a paper copy of the original topographic map will be issued to the successful bidder.

Existing grades on the design cross sections or DTM's, where they do not match the locations of actual spot elevations shown on the topographic map, were developed by computer interpolation from those spot elevations. Prior to disturbing original grade, Contractor shall verify the accuracy of the existing ground surface by verifying spot elevations at the same locations where original field survey data was obtained as indicated on the topographic map. Contractor shall recognize that, due to the interpolation process, the actual ground surface at any particular location may differ somewhat from the interpolated surface shown on the design cross sections or obtained from the DTM's. Contractor's verification of original ground surface, however, shall be limited to verification of spot elevations as indicated herein, and no adjustments will be made to the original ground surface unless the Contractor demonstrates that spot elevations shown are incorrect. For this purpose, spot elevations which are within 0.1 foot (30 mm) of the stated elevations for ground surfaces, or within 0.04 foot (12 mm) for hard surfaces (pavements, buildings, foundations, structures, etc.) shall be considered "no change". Only deviations in excess of these will be considered for adjustment of the original ground surface. If Contractor's verification identifies discrepancies in the topographic map, Contractor shall notify the RPR in writing at least two weeks before disturbance of existing grade to allow sufficient time to verify the submitted information and make adjustments to the design cross sections or DTM's. Disturbance of existing grade in any area shall constitute acceptance by the Contractor of the accuracy of the original elevations shown on the topographic map for that area.

All areas to be excavated shall be stripped of vegetation and topsoil. Topsoil shall be stockpiled for future use in areas designated on the plans or by the RPR. All suitable excavated material shall be used in the formation of embankment, subgrade, or other purposes as shown on the plans. All unsuitable material shall be disposed of as shown on the plans.

The grade shall be maintained so that the surface is well drained at all times.
When the volume of the excavation exceeds that required to construct the embankments to the grades as indicated on the plans, the excess shall be used to grade the areas of ultimate development or disposed as directed by the RPR. When the volume of excavation is not sufficient for constructing the embankments to the grades indicated, the deficiency shall be obtained from borrow areas.

a. **Selective grading.** When selective grading is indicated on the plans, the more suitable material designated by the RPR shall be used in constructing the embankment or in capping the pavement subgrade. If, at the time of excavation, it is not possible to place this material in its final location, it shall be stockpiled in approved areas until it can be placed. The more suitable material shall then be placed and compacted as specified. Selective grading shall be considered incidental to the work involved. The cost of stockpiling and placing the material shall be included in the various pay items of work involved.

b. **Undercutting.** Rock, shale, hardpan, loose rock, boulders, or other material unsatisfactory for safety areas, subgrades, roads, shoulders, or any areas intended for turf shall be excavated to a minimum depth of 12 inches (300 mm) below the subgrade or to the depth specified by the RPR. Muck, peat, matted roots, or other yielding material, unsatisfactory for subgrade foundation, shall be removed to the depth specified. Unsuitable materials shall be disposed off the airport. The cost is incidental to this item. This excavated material shall be paid for at the contract unit price per cubic yard (per cubic meter) for unclassified excavation. The excavated area shall be backfilled with suitable material obtained from the grading operations or borrow areas and compacted to specified densities. The necessary backfill will constitute a part of the embankment. Where rock cuts are made, backfill with select material. Any pockets created in the rock surface shall be drained in accordance with the details shown on the plans. Undercutting will be paid as unclassified excavation.

c. **Over-break.** Over-break, including slides, is that portion of any material displaced or loosened beyond the finished work as planned or authorized by the RPR. All over-break shall be graded or removed by the Contractor and disposed of as directed by the RPR. The RPR shall determine if the displacement of such material was unavoidable and their own decision shall be final. Payment will not be made for the removal and disposal of over-break that the RPR determines as avoidable. Unavoidable over-break will be classified as "Unclassified Excavation."

d. **Removal of utilities.** The removal of existing structures and utilities required to permit the orderly progress of work will be accomplished by the Contractor as indicated on the plans. All existing foundations shall be excavated at least 2 feet (60 cm) below the top of subgrade or as indicated on the plans, and the material disposed of as directed by the RPR. All foundations thus excavated shall be backfilled with suitable material and compacted as specified for embankment or as shown on the plans.

**152-2.3 Borrow excavation.** Borrow areas are not required.

**152-2.4 DRAINAGE EXCAVATION.** Drainage excavation shall consist of excavating drainage ditches including intercepting, inlet, or outlet ditches; or other types as shown on the plans. The work shall be performed in sequence with the other construction. Ditches shall be constructed prior to starting adjacent excavation operations. All satisfactory material shall be placed in embankment fills; unsuitable material shall be placed in designated waste areas or as directed by the RPR. All necessary work shall be performed true to final line, elevation, and cross-section. The Contractor shall maintain ditches constructed on the project to the required cross-section and shall keep them free of debris or obstructions until the project is accepted.

**152-2.5 PREPARATION OF CUT AREAS OR AREAS WHERE EXISTING PAVEMENT HAS BEEN REMOVED.** In those areas on which a subbase or base course are to be placed, or under any areas to
be paved, the subgrade shall be tested for moisture and densities in accordance with Section 152-2.12 Subgrade Preparation.

On all areas outside of the pavement areas, no compaction will be required on the top 4 in (100 mm). The lower layers shall be compacted to 95% of the maximum density from ASTM D 1557 for non-cohesive soils and 90% for cohesive soil.

All acceptance testing for embankments, excavations, and subgrades, shall be done by a laboratory hired by the Engineer. All testing for quality control shall be done by a laboratory hired by the Contractor.

152-2.6 PREPARATION OF EMBANKMENT AREA. No placement of embankment material shall be started until the work has been staked out by the Contractor and the Engineer has obtained current elevations and measurements of the ground surface from the Contractor in a complete and usable format. All sod and vegetable matter shall be removed from the surface upon which the embankment is to be placed, and the cleared surface shall be completely broken up by plowing or scarifying to a minimum depth of 6 in (150 mm).

Sloped surfaces steeper than one (1) vertical to four (4) horizontal shall be plowed, stepped, benched, or broken up so that the fill material will bond with the existing material. When the subgrade is part fill and part excavation or natural ground, the excavated or natural ground portion shall be scarified to a depth of 12 inches (300 mm) and compacted as specified for the adjacent fill.

No direct payment shall be made for the work performed under this section. The necessary clearing and grubbing and the quantity of excavation removed will be paid for under the respective items of work.

152-2.7 CONTROL STRIP. The first half-day of construction of subgrade and/or embankment shall be considered as a control strip for the Contractor to demonstrate, in the presence of the RPR, that the materials, equipment, and construction processes meet the requirements of this specification. The sequence and manner of rolling necessary to obtain specified density requirements shall be determined. The maximum compacted thickness may be increased to a maximum of 12 inches (300 mm) upon the Contractor’s demonstration that approved equipment and operations will uniformly compact the lift to the specified density. The RPR must witness this demonstration and approve the lift thickness prior to full production.

Control strips that do not meet specification requirements shall be reworked, re-compacted, or removed and replaced at the Contractor’s expense. Full operations shall not begin until the control strip has been accepted by the RPR. The Contractor shall use the same equipment, materials, and construction methods for the remainder of construction, unless adjustments made by the Contractor are approved in advance by the RPR.

152-2.8 FORMATION OF EMBANKMENTS. The material shall be constructed in lifts as established in the control strip, but not less than 6 inches (150 mm) nor more than 12 inches (300 mm) of compacted thickness.

When more than one lift is required to establish the layer thickness shown on the plans, the construction procedure described here shall apply to each lift. No lift shall be covered by subsequent lifts until tests verify that compaction requirements have been met. The Contractor shall rework, re-compact and retest any material placed which does not meet the specifications.

The lifts shall be placed, to produce a soil structure as shown on the typical cross-section or as directed by the RPR. Materials such as brush, hedge, roots, stumps, grass and other organic matter, shall not be incorporated or buried in the embankment.

Earthwork operations shall be suspended at any time when satisfactory results cannot be obtained due to rain, freezing, or other unsatisfactory weather conditions in the field. Frozen material shall not be placed in the embankment nor shall embankment be placed upon frozen material. Material shall not be placed on
surfaces that are muddy, frozen, or contain frost. The Contractor shall drag, blade, or slope the embankment to provide surface drainage at all times.

The material in each lift shall be within ±2% of optimum moisture content before rolling to obtain the prescribed compaction. The material shall be moistened or aerated as necessary to achieve a uniform moisture content throughout the lift. Natural drying may be accelerated by blending in dry material or manipulation alone to increase the rate of evaporation.

The Contractor shall make the necessary corrections and adjustments in methods, materials or moisture content to achieve the specified embankment density.

The RPR will take samples of excavated materials which will be used in embankment for testing and develop a Moisture-Density Relations of Soils Report (Proctor) in accordance with D 1557. A new Proctor shall be developed for each soil type based on visual classification.

Density tests will be taken by the RPR for every 1,000 square yards of compacted embankment for each lift which is required to be compacted, or other appropriate frequencies as determined by the RPR.

If the material has greater than 30% retained on the 3/4-inch (19.0 mm) sieve, follow AASHTO T-180 Annex Correction of maximum dry density and optimum moisture for oversized particles.

Rolling operations shall be continued until the embankment is compacted to not less than 100% of maximum density for non-cohesive soils, and 95% of maximum density for cohesive soils as determined by ASTM D 1557. Under all areas to be paved, the embankments shall be compacted to a depth of 12 inches and to a density of not less than 95% of maximum density for cohesive soils and 100 percent of the maximum density as determined by ASTM D 1557. As used in this specification, "non-cohesive" shall mean those soils having a plasticity index (PI) of less than 3 as determined by ASTM D4318. Expansive soils shall be defined as soils having percent swells of greater than 3 percent (as determined by ASTM D 1883).

On all areas outside of the pavement areas, no compaction will be required on the top 4 inches (100 mm) which shall be prepared for a seedbed in accordance with Item T-901. The lower layers shall be compacted to 95% of the maximum density from ASTM D 698 for non-cohesive soils and 90% for cohesive soil.

The in-place field density shall be determined in accordance with ASTM D 1556, ASTM D 2167, or ASTM D 6938 using Procedure A, the direct transmission method, and ASTM D6938 shall be used to determine the moisture content of the material. The machine shall be calibrated in accordance with ASTM D6938. Stones or rock fragments larger than 4 inches (100 mm) in their greatest dimension will not be permitted in the top 6 inches (150 mm) of the subgrade. The finished grading operations, conforming to the typical cross section, shall be completed and maintained at least 1,000 feet (300 m) ahead of the paving operations or as directed by the Engineer.

The RPR shall perform all density tests. If the specified density is not attained, the area represented by the test or as designated by the RPR shall be reworked and/or re-compacted and additional random tests made. This procedure shall be followed until the specified density is reached.

Compaction areas shall be kept separate, and no lift shall be covered by another lift until the proper density is obtained.

During construction of the embankment, the Contractor shall route all construction equipment evenly over the entire width of the embankment as each lift is placed. Lift placement shall begin in the deepest portion of the embankment fill. As placement progresses, the lifts shall be constructed approximately parallel to the finished pavement grade line.
When rock, concrete pavement, asphalt pavement, and other embankment material are excavated at approximately the same time as the subgrade, the material shall be incorporated into the outer portion of the embankment and the subgrade material shall be incorporated under the future paved areas. Stones, fragmentary rock, and recycled pavement larger than 4 inches (100 mm) in their greatest dimensions will not be allowed in the top 12 inches (300 mm) of the subgrade. Rockfill shall be brought up in lifts as specified or as directed by the RPR and the finer material shall be used to fill the voids forming a dense, compact mass. Rock, cement concrete pavement, asphalt pavement, and other embankment material shall not be disposed of except at places and in the manner designated on the plans or by the RPR.

When the excavated material consists predominantly of rock fragments of such size that the material cannot be placed in lifts of the prescribed thickness without crushing, pulverizing or further breaking down the pieces, such material may be placed in the embankment as directed in lifts not exceeding 2 feet (60 cm) in thickness. Each lift shall be leveled and smoothed with suitable equipment by distribution of spalls and finer fragments of rock. The lift shall not be constructed above an elevation 4 feet (1.2 m) below the finished subgrade.

There will be no separate measurement of payment for compacted embankment. All costs incidental to placing in lifts, compacting, discing, watering, mixing, sloping, and other operations necessary for construction of embankments will be included in the contract price for excavation, borrow, or other items.

**152-2.9 PROOF ROLLING.** The purpose of proof rolling the subgrade is to identify any weak areas in the subgrade and not for compaction of the subgrade. Before start of embankment, and after compaction is completed, the subgrade area shall be proof rolled with a 20 ton (18.1 metric ton Tandem axle Dual Wheel Dump Truck loaded to the legal limit with tires inflated to 80/100/150 psi (0.551 MPa/0.689 MPa/1.034 MPa) in the presence of the RPR. Apply a minimum of 100 percent coverage, or as specified by the RPR, under pavement areas. A coverage is defined as the application of one tire print over the designated area. Soft areas of subgrade that deflect more than 1 inch (25 mm) or show permanent deformation greater than 1 inch (25 mm) shall be removed and replaced with suitable material or reworked to conform to the moisture content and compaction requirements in accordance with these specifications. Removal and replacement of soft areas is incidental to this item.

**152-2.10 COMPACTION REQUIREMENTS.** The subgrade under any areas to be paved shall be compacted in accordance with Section 152-2.12 Subgrade Preparation.

The material to be compacted shall be within ±2% of optimum moisture content before being rolled to obtain the prescribed compaction (except for expansive soils). When the material has greater than 30 percent retained on the ¾ inch (19.0 mm) sieve, follow the methods in ASTM D1557 and procedures in AASHTO T180 Annex for correction of maximum dry density and optimum moisture for oversized particles. Tests for moisture content and compaction will be taken at a minimum of 1,000 S.Y. of subgrade. All quality assurance testing shall be done by the RPR.

The in-place field density shall be determined in accordance with ASTM D1556 or ASTM D6938 using Procedure A, the direct transmission method, and ASTM D6938 shall be used to determine the moisture content of the material. The machine shall be calibrated in accordance with ASTM D6938 within 12 months prior to its use on this contract. The gage shall be field standardized daily.

Maximum density refers to maximum dry density at optimum moisture content unless otherwise specified. If the specified density is not attained, the entire lot shall be reworked and/or re-compacted and additional random tests made. This procedure shall be followed until the specified density is reached.

All cut-and-fill slopes shall be uniformly dressed to the slope, cross-section, and alignment shown on the plans or as directed by the RPR and the finished subgrade shall be maintained.

**152-2.11 FINISHING AND PROTECTION OF SUBGRADE.** Finishing and protection of the subgrade is incidental to this item. Grading and compacting of the subgrade shall be performed so that it will drain readily. All low areas, holes or depressions in the subgrade shall be brought to grade. Scarifying, blading,
rolling and other methods shall be performed to provide a thoroughly compacted subgrade shaped to the
lines and grades shown on the plans. All ruts or rough places that develop in the completed subgrade
shall be graded, re-compacted, and retested. The Contractor shall protect the subgrade from damage and
limit hauling over the finished subgrade to only traffic essential for construction purposes.

The Contractor shall maintain the completed course in satisfactory condition throughout placement of
subsequent layers. No subbase, base, or surface course shall be placed on the subgrade until the
subgrade has been accepted by the RPR.

152-2.12 SUBGRADE PREPARATION. In excavation and embankment sections, subgrade under areas
to be paved shall be compacted to a depth of 12 inches and to a density of not less than 100% of
maximum density for non-cohesive soils, and 95% of maximum density for cohesive soils as determined
by ASTM D 1557. The material to be compacted shall be within +/-2 percent of optimum moisture content
before rolled to obtain the prescribed compaction (except for expansive soils). This item includes the
removal, blending/processing and re-compaction of 12 inches of material under proposed pavement
sections.

The in-place field density shall be determined in accordance with ASTM D 1556, ASTM D 2167, or ASTM
D 6938 using Procedure A, the direct transmission method, and ASTM D6938 shall be used to determine
the moisture content of the material. The machine shall be calibrated in accordance with ASTM D6938.
Stones or rock fragments larger than 4 inches (100 mm) in their greatest dimension will not be permitted
in the top 6 inches (150 mm) of the subgrade. The finished grading operations, conforming to the typical
cross section, shall be completed and maintained at least 1,000 feet (300 m) ahead of the paving
operations or as directed by the Engineer.

All acceptance testing for embankments, excavations, and subgrades, shall be done by a laboratory hired
by the RPR. All testing for quality control shall be done by a laboratory hired by the Contractor.

Construction of subgrade shall be by maximum 8-inch lifts and minimum 3-inch lifts. In order to achieve
uniform moisture content throughout the layer, wetting or drying of the material and manipulation shall be
required when necessary. Should the material be too wet to permit proper compaction or rolling, all work
on all of the affected portions of the embankment shall be delayed until the material has dried to the
required moisture content. Sprinkling of dry material to obtain the proper moisture content shall be done
with approved equipment that will sufficiently distribute the water. Sufficient equipment to furnish the
required water shall be available at all times. Samples of all subgrade materials for testing will be taken
for each 500 square yards for acceptance. Based on these tests, the Contractor shall make the
necessary corrections and adjustments in methods, materials or moisture content in order to achieve the
correct subgrade density.

152-2.13 HAUL. All hauling will be considered a necessary and incidental part of the work. The
Contractor shall include the cost in the contract unit price for the pay of items of work involved. No
payment will be made separately or directly for hauling on any part of the work.

The Contractor's equipment shall not cause damage to any excavated surface, compacted lift or to the
subgrade as a result of hauling operations. Any damage caused as a result of the Contractor's hauling
operations shall be repaired at the Contractor's expense.

The Contractor shall be responsible for providing, maintaining and removing any haul roads or routes
within or outside of the work area, and shall return the affected areas to their former condition, unless
otherwise authorized in writing by the Owner. No separate payment will be made for any work or
materials associated with providing, maintaining and removing haul roads or routes.

152-2.14 SURFACE TOLERANCES. In those areas on which a subbase or base course is to be placed,
the surface shall be tested for smoothness and accuracy of grade and crown. Any portion lacking the
required smoothness or failing in accuracy of grade or crown shall be scarified to a depth of at least 3
inches (75 mm), reshaped and re-compacted to grade until the required smoothness and accuracy are
obtained and approved by the RPR. The Contractor shall perform all final smoothness and grade checks in the presence of the RPR. Any deviation in surface tolerances shall be corrected by the Contractor at the Contractor’s expense.

a. **Smoothness.** The finished surface shall not vary more than +/- ½ inch (12 mm) when tested with a 12-foot (3.7-m) straightedge applied parallel with and at right angles to the centerline. The straightedge shall be moved continuously forward at half the length of the 12-foot (3.7-m) straightedge for the full length of each line on a 50-foot (15-m) grid.

b. **Grade.** The grade and crown shall be measured on a 50-foot (15-m) grid and shall be within +/-0.05 feet (15 mm) of the specified grade.

On safety areas, turfed areas and other designated areas within the grading limits where no subbase or base is to placed, grade shall not vary more than 0.10 feet (30 mm) from specified grade. Any deviation in excess of this amount shall be corrected by loosening, adding or removing materials, and reshaping.

**152-2.15 TOPSOIL.** Not used on this project.

**METHOD OF MEASUREMENT**

**152-3.1** Measurement for payment specified by the cubic yard (cubic meter) shall be computed by the comparison of digital terrain model (DTM) surfaces for computation of neat line design quantities. The end area is that bound by the original ground line established by field cross-sections and the final theoretical pay line established by cross-sections shown on the plans, subject to verification by the RPR.

**152-3.2** The quantity of unclassified excavation to be paid for shall be the number of cubic yards (cubic meters) measured in its original position. Measurement shall not include the quantity of materials excavated without authorization beyond normal slope lines, or the quantity of material used for purposes other than those directed.

**152-3.3** Subgrade preparation shall be measured on the basis of the number of approved square yards graded or prepared to accept material for future pavement sections.

**152-3.4** The quantity of over excavation to be measured for shall be the number of cubic yards (cubic meters) measured in its original position.

**BASIS OF PAYMENT**

**152-4.1** Unclassified excavation payment shall be made at the contract unit price per cubic yard (cubic meter). This price shall be full compensation for furnishing all materials, labor, equipment, tools, and incidentals necessary to complete the item.

**152-4.2** For subgrade preparation payment shall be made at the contract unit price per square yard (square meter). This price shall be full compensation for furnishing all materials, labor, equipment, tools, and incidentals necessary to complete the item.

**152-4.3** Over excavation payment shall be made at the contract unit price per cubic yard (cubic meter). This price shall be full compensation for furnishing all materials, labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be incidental to the project bid.
REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

American Association of State Highway and Transportation Officials (AASHTO)

AASHTO T-180 Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop

ASTM International (ASTM)

ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft$^3$ (600 kN-m/m$^3$))

ASTM D1556 Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method

ASTM D1557 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft$^3$ (2700 kN-m/m$^3$))

ASTM D6938 Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

Advisory Circulars (AC)

AC 150/5370-2 Operational Safety on Airports During Construction Software

FAARFIELD – FAA Rigid and Flexible Iterative Elastic Layered Design

U.S. Department of Transportation

FAA RD-76-66 Design and Construction of Airport Pavements on Expansive Soils

**END OF ITEM P-152**
ITEM P-154 SUBBASE COURSE

DESCRIPTION

154-1.1 This item shall consist of a subbase course composed of granular materials constructed on a prepared subgrade or underlying course in accordance with these specifications, and in conformity with the dimensions and typical cross-section shown on the plans.

MATERIALS

154-2.1 MATERIALS. The subbase material shall consist of hard durable particles or fragments of granular aggregates. The material may be obtained from gravel pits, stockpiles, or may be produced from a crushing and screening plant with proper blending. The materials from these sources shall meet the requirements for gradation, quality, and consistency. The material shall be free from vegetative matter, excessive amounts of clay, and other objectionable substances; uniformly blended; and be capable of being compacted into a dense, stable subbase.

The subbase material shall exhibit a California Bearing Ratio (CBR) value of at least 20 when tested in accordance with ASTM D1883. The subbase material shall meet the gradation specified in the table below.

Subbase Gradation Requirements

<table>
<thead>
<tr>
<th>Sieve designation</th>
<th>Percentage by weight passing sieves</th>
<th>Contractor's Final Grading</th>
<th>Job Control Grading Band Tolerances(^1) (Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Subbase Aggregate</td>
<td>Recycled pavement (RAP or RCO)</td>
<td></td>
</tr>
<tr>
<td>3 inch (75 mm)</td>
<td>100</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>1 1/2 inch (37.5 mm)</td>
<td>100</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>3/4 inch (19.0 mm)</td>
<td>70-100</td>
<td>70-100</td>
<td>±10</td>
</tr>
<tr>
<td>No. 10 (2.00 mm)</td>
<td>20-100</td>
<td>20-100</td>
<td>±10</td>
</tr>
<tr>
<td>No. 40 (425 µm)</td>
<td>5-60</td>
<td>5-60</td>
<td>±5</td>
</tr>
<tr>
<td>No. 200 (75 µm)</td>
<td>[ 0-15 ]</td>
<td>[ 0-15 ]</td>
<td>±5</td>
</tr>
</tbody>
</table>

\(^1\)The “Job Control Grading Band Tolerances” shall be applied to “Contractor’s Final Grading” to establish the job control grading band.

The portion of the material passing the No. 40 (425 µm) sieve shall have a liquid limit of not more than 25 and a plasticity index of not more than six (6) when tested in accordance with ASTM D4318.

154-2.2 SAMPLING AND TESTING.

a. **Aggregate base materials.** Samples shall be taken by the Contractor per ASTM D75 for initial aggregate subbase requirements and gradation. Material shall meet the requirements in paragraphs 154-2.1. The Contractor shall submit to the Resident Project Representative (RPR)
certified test results showing that the aggregate meets the Material requirements of this section. Tests shall be representative of the material to be used for the project.

b. **Gradation requirements.** The Contractor shall take at least one aggregate subbase sample per day in the presence of the RPR to check the final gradation. Samples shall be taken from the in-place, un-compacted material at sampling locations determined by the RPR on a random basis per ASTM D3665. Sampling shall be per ASTM D75 and tested per ASTM C136 and ASTM C117. Results shall be furnished to the RPR by the Contractor each day during construction. Material shall meet the requirements in paragraph 154-2.1.

154-2.3 **SEPARATION GEOTEXTILE.** Separation geotextile shall be Class 2; 0.02 sec⁻¹ permittivity per ASTM D4491; Apparent opening size per ASTM D4751 with 0.60 mm maximum average roll value. The separation geotextile shall be installed per the requirements of Item P-310 Geosynthetic Fabrics. Separation geotextile shall be utilized in locations shown in the plans or as directed by the RPR.

154-2.4 **GEOGRID.** Not used.

**CONSTRUCTION METHODS**

154-3.1 **GENERAL.** The subbase course shall be placed where designated on the plans or as directed by the RPR. The material shall be shaped and thoroughly compacted within the tolerances specified.

Granular subbases which, due to grain sizes or shapes, are not sufficiently stable to support the construction equipment without movement, shall be mechanically modified to the depth necessary to provide stability as directed by the RPR. The mechanical modification shall include the addition of a fine-grained medium to bind the particles of the subbase material sufficiently to furnish a bearing strength, so the course will not deform under construction equipment traffic.

154-3.2 **PREPARING UNDERLYING COURSE.** Prior to constructing the subbase course, clean the underlying course or subgrade of all foreign substances. The surface of the underlying course or subgrade shall meet specified compaction and surface tolerances in accordance with Item P-152. Correct ruts, soft yielding spots in the underlying courses, and subgrade areas having inadequate compaction and/or deviations of the surface from the specified requirements, by loosening and removing soft or unsatisfactory material, adding approved material, reshaping to line and grade, and recompacting to specified density requirements. For cohesionless underlying courses or subgrades containing sands or gravels, as defined in ASTM D2487, the surface shall be stabilized prior to placement of the overlying course by mixing the overlying course material into the underlying course, and compacting by approved methods. The stabilized material shall be considered as part of the underlying course and shall meet all requirements for the underlying course. The finished underlying course shall not be disturbed by traffic or other operations and shall be maintained in a satisfactory condition until the overlying course is placed. The underlying course shall be checked and accepted by the RPR before placing and spreading operations are started.

To protect the subgrade and to ensure proper drainage, spreading of the subbase shall begin along the centerline of the pavement on a crowned section or on the high side of pavements with a one-way slope.

154-3.3 **CONTROL STRIP.** The first half-day of subbase construction shall be considered as a control strip for the Contractor to demonstrate, in the presence of the RPR, that the materials, equipment, and construction processes meet the requirements of this specification. The sequence and manner of rolling necessary to obtain specified density requirements shall be determined. The maximum compacted thickness may be increased to a maximum of 12 inches (300 mm) upon the Contractor’s demonstration that approved equipment and operations will uniformly compact the lift to the specified density. The RPR must witness this demonstration and approve the lift thickness prior to full production. Control strips that do not meet specification requirements shall be reworked, re-compacted, or removed and replaced at the Contractor’s expense. Full operations shall not begin until the control strip has been accepted by the RPR. The Contractor shall use the same equipment, materials, and construction methods...
for the remainder of construction, unless adjustments made by the Contractor are approved in advance by the RPR.

154-3.4 PLACEMENT. The material shall be placed and spread on the prepared underlying layer by spreader boxes or other devices as approved by the RPR, to a uniform thickness and width. The equipment shall have positive thickness controls to minimize the need for additional manipulation of the material. Dumping from vehicles that require re-handling shall not be permitted. Hauling over the uncompacted base course shall not be permitted. The material shall not be placed when the underlying course is soft or yielding.

The material shall meet gradation and moisture requirements prior to compaction. Material may be free-draining and the minimum moisture content shall be established for placement and compaction of the material. The material shall be constructed in lifts as established in the control strip, but not less than 4 inches (100 mm) nor more than 12 inches (300 mm) of compacted thickness.

When more than one lift is required to establish the layer thickness shown on the plans, the construction procedure described here shall apply to each lift. No lift shall be covered by subsequent lifts until tests verify that compaction requirements have been met. The Contractor shall rework, re-compact and retest any material placed which does not meet the specifications.

154-3.5 COMPACTION. The subbase material shall be compacted, adjusting moisture as necessary, to be within ±2% of optimum moisture. The field density of the compacted material shall be at least 100% of the maximum density as specified in paragraph 154-3.9a. If the specified density is not attained, the area of the lift represented by the test shall be reworked and/or re-compacted and additional random tests made. This procedure shall be followed until the specified density is reached. Maximum density refers to maximum dry density at optimum moisture content unless otherwise specified.

154-3.6 WEATHER LIMITATION. Material shall not be placed unless the ambient air temperature is at least 40°F (4°C) and rising. Work on subbase course shall not be conducted when the subgrade is wet or frozen or the subbase material contains frozen material.

154-3.7 MAINTENANCE. No base or surface course shall be placed on the subbase until the subbase has been accepted by the RPR. The Contractor shall maintain the completed course in satisfactory condition throughout placement of subsequent layers. When material has been exposed to excessive rain, snow, or freeze-thaw conditions, the Contractor shall verify that materials still meet all specification requirements before placement of additional material. Equipment may be routed over completed sections of subbase course, provided the equipment does not damage the subbase course and the equipment is routed over the full width of the completed subbase course. Any damage to the subbase course from routing equipment over the subbase course shall be repaired by the Contractor at their expense.

154-3.8 SURFACE TOLERANCE. In those areas on which a subbase or base course is to be placed, the surface shall be tested for smoothness and accuracy of grade and crown. Any portion lacking the required smoothness or failing in accuracy of grade or crown shall be scarified to a depth of at least 3 inches (75 mm), reshaped and re-compacted to grade until the required smoothness and accuracy are obtained and approved by the RPR. The Contractor shall perform all final smoothness and grade checks in the presence of the RPR. Any deviation in surface tolerances shall be corrected by the Contractor at the Contractor’s expense.

a. Smoothness. The finished surface shall not vary more than +/- ½ inch (12 mm) when tested with a 12-foot (3.7-m) straightedge applied parallel with and at right angles to the centerline. The straightedge shall be moved continuously forward at half the length of the 12-foot (3.7-m) straightedge for the full length of each line on a 50-foot (15-m) grid.

b. Grade. The grade and crown shall be measured on a 50-foot (15-m) grid and shall be within +/-0.05 feet (15 mm) of the specified grade.
A 12-foot straight edge shall be provided by the contractor, and made available to the engineer at all times for testing of surface smoothness tolerances.

154-3.9 ACCEPTANCE SAMPLING AND TESTING. The aggregate base course shall be accepted for density and thickness on an area basis. Two tests shall be made for density and thickness for each 1200 square yards (1000 square meters). Sampling locations will be determined on a random basis per ASTM D3665.

a. Density. The RPR shall perform all density tests.

   Each area shall be accepted for density when the field density is at least 100% of the maximum density of laboratory specimens compacted and tested per ASTM D1557. The in-place field density shall be determined per ASTM D1556 or ASTM D6938 using Procedure A, the direct transmission method, and ASTM D6938 shall be used to determine the moisture content of the material. The machine shall be calibrated in accordance with ASTM D6938. If the specified density is not attained, the area represented by the failed test shall be reworked and/or recompacted and two additional random tests made. This procedure shall be followed until the specified density is reached. Maximum density refers to maximum dry density at optimum moisture content unless otherwise specified.

   When the material has greater than 30 percent retained on the ¾ inch (19.0 mm) sieve, use methods in ASTM D1557 and the procedures in AASHTO T180 Annex for correction of maximum dry density and optimum moisture for oversized particles.

b. Thickness. The thickness of the base course shall be within +0 and -1/2 inch (12 mm) of the specified thickness as determined by depth tests taken by the Contractor in the presence of the RPR for each area. Where the thickness is deficient by more than 1/2-inch (12 mm), the Contractor shall correct such areas at no additional cost by scarifying to a depth of at least 3 inches (75 mm), adding new material of proper gradation, and the material shall be blended and recompacted to grade. The Contractor shall replace, at his expense, base material where depth tests have been taken.

METHOD OF MEASUREMENT

154-4.1 Subbase course shall be measured by the number of cubic yards (cubic meters) of subbase course material placed and compacted to specified density and plan thickness requirements in the completed course. The quantity of subbase course material shall be measured in final position based upon depth tests or cores taken as directed by the RPR, at the rate of two tests per each 1200 square yards (1000 square meters) of subbase course or survey of the completed work computed from elevations to the nearest 0.01 foot (3 mm). On individual depth measurements, thicknesses more than 1/2 inch (12 mm) in excess of that shown on the plans shall be considered as the specified thickness plus 1/2 inch (12 mm) in computing the yardage for payment. Subbase materials shall not be included in any other excavation quantities.

154-4.2 Separation geotextile shall be measured in accordance with Item P-310.

BASIS OF PAYMENT

154-5.1 Payment shall be made at the contract unit price per cubic yard (cubic meter) for subbase course. This price shall be full compensation for furnishing all materials; for all preparation, hauling, and placing of these materials; and for all labor, equipment, tools, and incidental needed to complete the item.

154-5.2 Payment shall be made for Separation Geotextile in accordance with Item P-310.

Payment will be incident to the project bid.
REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM International (ASTM)

ASTM C117  Standard Test Method for Materials Finer than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing


ASTM D75  Standard Practice for Sampling Aggregates

ASTM D698  Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³))

ASTM D1556  Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method

ASTM D1557  Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN-m/m³))

ASTM D2487  Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

ASTM D4253  Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table

ASTM D4759  Practice for Determining the Specification Conformance of Geosynthetics


ASTM D6938  Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

American Association of State Highway and Transportation Officials (AASHTO)

M 288  Geotextile Specification for Highway Applications

**END OF ITEM P-154**
ITEM P-159 WATERING

DESCRIPTION

159-1.1 This item shall consist of furnishing and applying water required in the compaction of embankments, subgrades, subbases, base courses, for concrete and for other purposes in accordance with the requirements of these specifications or as designated by the Engineer.

MATERIALS

159-2.1 WATER SOURCES. Water is not available for construction purposes on the airport property. The Contractor shall obtain a suitable water source off of airport property for his/her use in accomplishing the work.

159-2.2 WATER QUALITY FOR EARTHWORK. Water required in the compaction of embankments, subgrades, subbases and base courses shall be as clean and free of sewage, oil, strong alkalis, vegetable matter, and other substances injurious to the finished product as possible. Where the source of water is relatively shallow, the intake shall be so enclosed as to exclude silt, mud, grass, or other foreign materials.

159-2.3 WATER QUALITY FOR CONCRETE. Water used in mixing or curing concrete shall be from potable water sources. Other sources shall be tested in accordance with ASTM C1602 prior to use.

CONSTRUCTION METHODS

159-3.1 GENERAL. Water shall be applied at the locations, in the amounts, and during the hours, including nights, as required, or as designated by the Engineer. An adequate water supply shall be provided by the Contractor. The equipment used for watering shall be of ample capacity and of such design as to assure uniform application of water in the amounts required.

159-3.2 HAUL. No payment will be made separately or directly for haul of water on any part of the work. All hauling will be considered a necessary and incidental part of the work, and its cost shall be considered by the Contractor and included in the contract unit price for the pay items of work involved.

METHOD OF MEASUREMENT

159-4.1 MEASUREMENT. No measurement will be made separately or directly for water on any part of the work.

BASIS OF PAYMENT

159-5.1 PAYMENT. No payment will be made separately or directly for water on any part of the work. All water will be considered a necessary and incidental part of the work and its cost shall be considered by the Contractor and included in the contract unit price for the pay items of work involved.

TESTING AND MATERIAL REQUIREMENTS

<table>
<thead>
<tr>
<th>Test and Short Title</th>
<th>Material and Short Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM C1602</td>
<td>Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete</td>
</tr>
</tbody>
</table>

**END OF ITEM P-159**
ITEM P-209 CRUSHED AGGREGATE BASE COURSE

DESCRIPTION

209-1.1 This item consists of a base course composed of crushed aggregate base constructed on a prepared course in accordance with these specifications and in conformity to the dimensions and typical cross-sections shown on the plans.

MATERIALS

209-2.1 CRUSHED AGGREGATE BASE. Crushed aggregate shall consist of clean, sound, durable particles of crushed stone, crushed gravel, and shall be free from coatings of clay, silt, organic material, clay lumps or balls or other deleterious materials or coatings. The method used to produce the crushed gravel shall result in the fractured particles in the finished product as consistent and uniform as practicable. Fine aggregate portion, defined as the portion passing the No. 4 (4.75 mm) sieve shall consist of fines from the coarse aggregate crushing operation. The fine aggregate shall be produced by crushing stone, gravel, that meet the coarse aggregate requirements for wear and soundness. Aggregate base material requirements are listed in the following table.

CRUSHED AGGREGATE BASE MATERIAL REQUIREMENTS

<table>
<thead>
<tr>
<th>Material Test</th>
<th>Requirement</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance to Degradation</td>
<td>Loss: 45% maximum</td>
<td>ASTM C131</td>
</tr>
<tr>
<td>Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate</td>
<td>Loss after 5 cycles: 12% maximum using Sodium sulfate - or - 18% maximum using magnesium sulfate</td>
<td>ASTM C88</td>
</tr>
<tr>
<td>Percentage of Fractured Particles</td>
<td>Minimum 90% by weight of particles with at least two fractured faces and 100% with at least one fractured face¹</td>
<td>ASTM D5821</td>
</tr>
<tr>
<td>Flat Particles, Elongated Particles, or Flat and Elongated Particles</td>
<td>10% maximum, by weight, of flat, elongated, or flat and elongated particles ²</td>
<td>ASTM D4791</td>
</tr>
<tr>
<td>Clay lumps and friable particles</td>
<td>Less than or equal to 3 percent</td>
<td>ASTM C142</td>
</tr>
</tbody>
</table>

Fine Aggregate

<table>
<thead>
<tr>
<th>Material Test</th>
<th>Requirement</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid limit</td>
<td>Less than or equal to 25</td>
<td>ASTM D4318</td>
</tr>
<tr>
<td>Plasticity Index</td>
<td>Not more than five (5)</td>
<td>ASTM D4318</td>
</tr>
</tbody>
</table>

¹ The area of each face shall be equal to at least 75% of the smallest mid-sectional area of the piece. When two fractured faces are contiguous, the angle between the planes of fractures shall be at least 30 degrees to count as two fractured faces.

² A flat particle is one having a ratio of width to thickness greater than five (5); an elongated particle is one having a ratio of length to width greater than five (5).

209-2.2 GRADATION REQUIREMENTS. The gradation of the aggregate base material shall meet the requirements of the gradation given in the following table when tested per ASTM C117 and ASTM C136. The gradation shall be well graded from coarse to fine and shall not vary from the lower limit on one sieve to the high limit on an adjacent sieve or vice versa.
GRADATION OF AGGREGATE BASE

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Design Range Percentage by Weight passing</th>
<th>Contractor's Final Gradation</th>
<th>Job Control Grading Band Tolerances$^1$ (Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 inch (50 mm)</td>
<td>100</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>1-1/2 inch (37.5 mm)</td>
<td>95-100</td>
<td></td>
<td>±5</td>
</tr>
<tr>
<td>1 inch (25.0 mm)</td>
<td>70-95</td>
<td></td>
<td>±8</td>
</tr>
<tr>
<td>3/4 inch (19.0 mm)</td>
<td>55-85</td>
<td></td>
<td>±8</td>
</tr>
<tr>
<td>No. 4 (4.75 mm)</td>
<td>30-60</td>
<td></td>
<td>±8</td>
</tr>
<tr>
<td>No. 40 $^2$ (425 µm)</td>
<td>10-30</td>
<td></td>
<td>±5</td>
</tr>
<tr>
<td>No. 200 $^2$ (75 µm)</td>
<td>0-10</td>
<td></td>
<td>±3</td>
</tr>
</tbody>
</table>

$^1$The “Job Control Grading Band Tolerances for Contractor’s Final Gradation” in the table shall be applied to “Contractor’s Final Gradation” to establish a job control grading band. The full tolerance still applies if application of the tolerances results in a job control grading band outside the design range.

$^2$ The fraction of material passing the No 200 (75 µm) sieve shall not exceed two-thirds the fraction passing the No 40 (425 µm) sieve.

209-2.3 SAMPLING AND TESTING.

a. **Aggregate base materials.** The Contractor shall take samples of the aggregate base in accordance with ASTM D75 to verify initial aggregate base requirements and gradation. Material shall meet the requirements in paragraph 209-2.1. This sampling and testing will be the basis for approval of the aggregate base quality requirements.

b. **Gradation requirements.** The Contractor shall take at least two aggregate base samples per day in the presence of the Resident Project Representative (RPR) to check the final gradation. Sampling shall be per ASTM D75. Material shall meet the requirements in paragraph 209-2.2. The samples shall be taken from the in-place, un-compacted material at sampling points and intervals designated by the RPR.

209-2.4 SEPARATION GEOTEXTILE. **Not used.**

CONSTRUCTION METHODS

209-3.1 CONTROL STRIP. The first half-day of construction shall be considered the control strip. The Contractor shall demonstrate, in the presence of the RPR, that the materials, equipment, and construction processes meet the requirements of the specification. The sequence and manner of rolling necessary to obtain specified density requirements shall be determined. The maximum compacted thickness may be increased to a maximum of 12 inches (300 mm) upon the Contractor’s demonstration that approved equipment and operations will uniformly compact the lift to the specified density. The RPR must witness this demonstration and approve the lift thickness prior to full production.

Control strips that do not meet specification requirements shall be reworked, re-compacted or removed and replaced at the Contractor’s expense. Full operations shall not continue until the control strip has
been accepted by the RPR. The Contractor shall use the same equipment, materials, and construction methods for the remainder of construction, unless adjustments made by the Contractor are approved by the RPR.

209-3.2 PREPARING UNDERLYING SUBGRADE AND/OR SUBBASE. The underlying subgrade and/or subbase shall be checked and accepted by the RPR before base course placing and spreading operations begin. Re-proof rolling of the subgrade or proof rolling of the subbase in accordance with Item P-152, at the Contractor's expense, may be required by the RPR if the Contractor fails to ensure proper drainage or protect the subgrade and/or subbase. Any ruts or soft, yielding areas due to improper drainage conditions, hauling, or any other cause, shall be corrected before the base course is placed. To ensure proper drainage, the spreading of the base shall begin along the centerline of the pavement on a crowned section or on the high side of the pavement with a one-way slope.

209-3.3 PRODUCTION. The aggregate shall be uniformly blended and, when at a satisfactory moisture content per paragraph 209-3.5, the approved material may be transported directly to the placement.

209-3.4 PLACEMENT. The aggregate shall be placed and spread on the prepared underlying layer by spreader boxes or other devices as approved by the RPR, to a uniform thickness and width. The equipment shall have positive thickness controls to minimize the need for additional manipulation of the material. Dumping from vehicles that require re-handling shall not be permitted. Hauling over the uncompacted base course shall not be permitted.

The aggregate shall meet gradation and moisture requirements prior to compaction. The base course shall be constructed in lifts as established in the control strip, but not less than 4 inches (100 mm) nor more than 12 inches (300 mm) of compacted thickness.

When more than one lift is required to establish the layer thickness shown on the plans, the construction procedure described here shall apply to each lift. No lift shall be covered by subsequent lifts until tests verify that compaction requirements have been met. The Contractor shall rework, re-compact and retest any material placed which does not meet the specifications at the Contractor's expense.

209-3.5 COMPACTION. Immediately after completion of the spreading operations, compact each layer of the base course, as specified, with approved compaction equipment. The number, type, and weight of rollers shall be sufficient to compact the material to the required density within the same day that the aggregate is placed on the subgrade.

The field density of each compacted lift of material shall be at least 100% of the maximum density of laboratory specimens prepared from samples of the base material delivered to the jobsite. The laboratory specimens shall be compacted and tested in accordance with ASTM D1557. The moisture content of the material during placing operations shall be within ±2 percentage points of the optimum moisture content as determined by ASTM D6938. Maximum density refers to maximum dry density at optimum moisture content unless otherwise specified.

209-3.6 WEATHER LIMITATIONS. Material shall not be placed unless the ambient air temperature is at least 40°F (4°C) and rising. Work on base course shall not be conducted when the subgrade or subbase is wet or frozen or the base material contains frozen material.

209-3.7 MAINTENANCE. The base course shall be maintained in a condition that will meet all specification requirements. When material has been exposed to excessive rain, snow, or freeze-thaw conditions, prior to placement of additional material, the Contractor shall verify that materials still meet all specification requirements. Equipment may be routed over completed sections of base course, provided that no damage results and the equipment is routed over the full width of the completed base course. Any damage resulting to the base course from routing equipment over the base course shall be repaired by the Contractor at the Contractor's expense.
209-3.8 SURFACE TOLERANCES. After the course has been compacted, the surface shall be tested for smoothness and accuracy of grade and crown. Any portion lacking the required smoothness or failing in accuracy of grade or crown shall be scarified to a depth of at least 3 inches (75 mm), reshaped and recompacted to grade until the required smoothness and accuracy are obtained and approved by the RPR. Any deviation in surface tolerances shall be corrected by the Contractor at the Contractor’s expense. The smoothness and accuracy requirements specified here apply only to the top layer when base course is constructed in more than one layer.

a. Smoothness. The finished surface shall not vary more than 3/8-inch (9 mm) when tested with a 12-foot (3.7-m) straightedge applied parallel with and at right angles to the centerline. The straightedge shall be moved continuously forward at half the length of the 12-foot (3.7-m) straightedge for the full length of each line on a 50-foot (15-m) grid.

b. Grade. The grade and crown shall be measured on a 50 foot (15-m) grid and be within +0 to -1/4 inch (6 mm) of the specified grade with no more than 25% of measurements exceeding -1/4 inch. No measurements exceeding -1/2 inches are allowed. If more that 25% exceed ¼ inch or any areas exceed ½ inch, the areas shall be reworked to bring into tolerances. Testing results shall be furnished daily to the Engineer for acceptance determination.

A 12-foot straight edge shall be provided by the contractor, and made available to the engineer at all times for testing of surface smoothness tolerances.

209-3.9 ACCEPTANCE SAMPLING AND TESTING. Crushed aggregate base course shall be accepted for density and thickness on an area basis. Two tests shall be made for density and thickness for each 1200 square yds (1000 m²). Sampling locations will be determined on a random basis per ASTM D3665.

a. Density. The RPR shall perform all density tests Contractor’s laboratory shall perform all density tests in the RPR’s presence and provide the test results upon completion to the RPR for acceptance.

Each area shall be accepted for density when the field density is at least 100% of the maximum density of laboratory specimens compacted and tested per ASTM 1557. The inplace field density shall be determined per ASTM D1556. or ASTM D6938 using Procedure A, the direct transmission method, and ASTM D6938 shall be used to determine the moisture content of the material. The machine shall be calibrated in accordance with ASTM D6938. If the specified density is not attained, the area represented by the failed test must be reworked and/or recompacted and two additional random tests made. This procedure shall be followed until the specified density is reached. Maximum density refers to maximum dry density at optimum moisture content unless otherwise specified.

b. Thickness. Depth tests shall be made by test holes at least 3 inches (75 mm) in diameter that extend through the base. The thickness of the base course shall be within +0 and -1/2 inch (12 mm) of the specified thickness as determined by depth tests taken by the Contractor in the presence of the RPR for each area. Where the thickness is deficient by more than 1/2-inch (12 mm), the Contractor shall correct such areas at no additional cost by scarifying to a depth of at least 3 inches (75 mm), adding new material of proper gradation, and the material shall be blended and recompacted to grade. The Contractor shall replace, at his expense, base material where depth tests have been taken. Lift thickness testing may also be performed via survey at no cost to the Sponsor. To accurately assess thicknesses by survey, Contractor shall provide electronic surveys to Engineer for both the underlying surface the base course is constructed on, and also the final surface of the base course. Shots for both surveys shall be shot on the same survey grid to allow for accurate determinations of thicknesses. Electronic survey shall be in a format approved by the Engineer.
METHOD OF MEASUREMENT

209-4.1 The quantity of crushed aggregate base course will be determined by measurement of the number of cubic yards (cubic meters) of material actually constructed and accepted by the RPR as complying with the plans and specifications. Base materials shall not be included in any other excavation quantities.

BASIS OF PAYMENT

209-5.1 Payment will be incidental to the project bid.

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM International (ASTM)

ASTM C29 Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate

ASTM C88 Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

ASTM C117 Standard Test Method for Materials Finer than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing


ASTM C136 Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregates

ASTM C142 Standard Test Method for Clay Lumps and Friable Particles in Aggregates

ASTM D75 Standard Practice for Sampling Aggregates

ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft$^3$ (600 kN-m/m$^3$))

ASTM D1556 Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method

ASTM D1557 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft$^3$ (2700 kN-m/m$^3$))

ASTM D2167 Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method


ASTM D3665 Standard Practice for Random Sampling of Construction Materials
ASTM D4491  Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D4643  Standard Test Method for Determination of Water Content of Soil and Rock by Microwave Oven Heating
ASTM D4751  Standard Test Methods for Determining Apparent Opening Size of a Geotextile
ASTM D4791  Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D5821  Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
ASTM D6938  Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D7928  Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis

American Association of State Highway and Transportation Officials (AASHTO)

M288  Standard Specification for Geosynthetic Specification for Highway Applications

**END OF ITEM P-209**
ITEM P-306 LEAN CONCRETE BASE COURSE

DESCRIPTION

306-1.1 This item shall consist of a lean concrete subbase material that is composed of aggregate and cement uniformly blended together and mixed with water. The mixture may also include approved cementitious additives, in the form of fly ash or slag, and chemical admixtures. The mixed material shall be spread, shaped, and consolidated using concrete paving equipment in accordance with these specifications and in conformity to the lines, grades, dimensions, and typical cross-sections shown on the plans.

MATERIALS

306-2.1 AGGREGATE. The coarse aggregate fraction shall be crushed stone, crushed or uncrushed gravel, crushed and adequately seasoned, air-cooled, iron blast furnace slag, crushed recycled concrete, or a combination thereof. The fine aggregate fraction may be part of the natural aggregate blend as obtained from the borrow source or it may be natural sand that is added at the time of mixing. The aggregate shall meet the gradation and material requirements in the tables below.

AGGREGATE MATERIAL REQUIREMENTS

<table>
<thead>
<tr>
<th>Material Test</th>
<th>Requirement</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse Aggregate Portion (retained on the No. 4 (4.75 mm) sieve)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resistance to Degradation</td>
<td>Loss: 40% maximum</td>
<td>ASTM C131</td>
</tr>
<tr>
<td>Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate</td>
<td>Loss after 5 cycles: 10% maximum using Sodium sulfate - or - 15% maximum using magnesium sulfate</td>
<td>ASTM C88</td>
</tr>
<tr>
<td>Flat Particles, Elongated Particles, or Flat and Elongated Particles&lt;sup&gt;1&lt;/sup&gt;</td>
<td>10% maximum, by weight, for fraction retained on the ½ inch (12.5mm) sieve and 10% maximum, by weight, for the fraction passing the 1/2-inch (12.5 mm) sieve</td>
<td>ASTM D4791</td>
</tr>
<tr>
<td>Clay lumps and friable particles</td>
<td>Less than or equal to 3 percent</td>
<td>ASTM C142</td>
</tr>
</tbody>
</table>

Fine Aggregate Portion (passing the No. 40 (425µm) sieve)

<table>
<thead>
<tr>
<th>Material Test</th>
<th>Requirement</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay lumps and friable particles</td>
<td>Less than or equal to 3 percent</td>
<td>ASTM C142</td>
</tr>
<tr>
<td>Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate</td>
<td>Loss after 5 cycles: 10% maximum using Sodium sulfate - or - 15% maximum using magnesium sulfate</td>
<td>ASTM C88</td>
</tr>
</tbody>
</table>

<sup>1</sup> A flat particle is one having a ratio of width to thickness greater than five (5); an elongated particle is one having a ratio of length to width greater than five (5).

AGGREGATE GRADATION FOR LEAN CONCRETE

<table>
<thead>
<tr>
<th>Sieve Size (square openings)</th>
<th>Percentage by Weight Passing Sieves</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
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</tr>
<tr>
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<td>70 - 100</td>
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<tr>
<td>No. 4 (4.75 mm)</td>
<td>35 - 65</td>
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<tr>
<td>No. 40 (425 µm)</td>
<td>15 - 30</td>
</tr>
<tr>
<td>No. 200 (75 µm)</td>
<td>0 - 15</td>
</tr>
</tbody>
</table>
306-2.2 SAMPLING AND TESTING.

a. Aggregate base materials. The Contractor shall take samples of the aggregate base stockpile in accordance with ASTM D75 to verify initial aggregate base requirements and gradation. Material shall meet the requirements in paragraphs 306-2.1 and 306-2.2. This sampling and testing will be the basis for approval of the aggregate base quality requirements.

306-2.3 CEMENT. Cement shall conform to the requirements of ASTM C 150, Type II.

306-2.4 CEMENTITIOUS ADDITIVES. Pozzolanic and slag cement may be added to the lean concrete mix. If used, each material must meet the following requirements:

a. Pozzolan. Pozzolanic materials must meet the requirements of ASTM C618, Class F, or N with the exception of loss of ignition, where the maximum shall be less than 6%. The supplementary optional physical requirements of Table 3 contained in ASTM C618 shall apply.

b. Slag cement (ground granulated blast furnace (GGBF) slag). Slag shall conform to ASTM C989, Grade 100 or 120.

306-2.5 CHEMICAL ADMIXTURES. The Contractor shall submit certificates indicating that the material to be furnished meets all the requirements listed below. In addition, the RPR may require the Contractor to submit complete test data showing that the material to be furnished meets all the requirements of the cited specification.

a. Air-entraining admixtures. Air-entraining admixtures shall meet the requirements of ASTM C260.

b. Water-reducing admixtures. Water-reducing, set-controlling admixtures shall meet the requirements of ASTM C494, Type A, D, E, F, or G. Water-reducing admixtures shall be added at the mixer separately from air-entraining admixtures in accordance with the manufacturer’s printed instructions. The air entrainment agent and the water-reducing admixture shall be compatible.

c. Retarding admixtures.

d. Accelerating admixtures. Accelerating admixtures shall meet the requirements of ASTM C494, Type C.

306-2.6 WATER. Water used in mixing or curing shall be from potable water sources. Other sources shall be tested in accordance with ASTM C1602 prior to use.

306-2.7 CURING MATERIALS. For curing lean concrete, use white-pigmented, liquid membrane-forming compound conforming to ASTM C309, Type 2, Class B, or clear or translucent Type 1-D, Class B with white fugitive dye.

306-2.8 BOND BREAKER. Fabric shall meet the requirements of Item P-314. A certificate of compliance (COC) shall be provided by the fabric manufacturer that the material may be used as a bond breaker.

COMPOSITION OF MIXTURE

306-3.1 MIX DESIGN. The lean concrete mix design shall be based on trial batch results conducted in the laboratory. The lean concrete shall be designed to meet the criteria in this section.

Compressive strength shall not be less than 500 pounds per square inch (3,445 kPa) nor greater than 800 pounds per square inch (5,516 kPa) at seven (7) days. Compressive strengths shall be taken as the average
of two compressive strength test results. All compressive strength specimens shall be prepared and tested in accordance with ASTM C192 and ASTM C39, respectively.

The percentage of air entrainment shall be 6%, ±1/2%. Air content shall be determined by testing in accordance with ASTM C231 for gravel and stone coarse aggregate and ASTM C173 for slag and other highly porous coarse aggregate.

If there is a change in aggregate sources, type of cement used, or pozzolanic materials, a new mix design must be submitted

306-3.2 SUBMITTALS. At least 30 days prior to the placement of the lean concrete, the Contractor shall submit certified test reports to the RPR for those materials proposed for use during construction, as well as the mix design information for the lean concrete material. The certification shall identify the specifications and test standard, the name of the testing laboratory, the date of the tests, and a statement that the materials comply with the applicable specifications. Tests older than six (6) months shall not be used. The submittal package shall include the following:

a. Sources of materials, including aggregate, cement, admixtures, and curing and bond breaking materials.

b. Physical properties of the aggregates, cement, admixtures, curing and bond breaking materials.

c. Mix design:

   Mix identification number
   - Weight of saturated surface-dry aggregates (fine and coarse)
   - Combined aggregate gradation
   - Cement factor
   - Water content
   - Water-cementitious material ratio (by weight)
   - Volume of admixtures and yield for one cubic yard (cubic meter) of lean concrete
   - Laboratory test results:
     - Slump
     - Unit weight
     - Air content
     - Compressive strength at 3, 7, and 28 days (average values)
     - Wet-dry and/or Freeze-thaw weight loss

Where applicable, the Contractor shall submit a jointing plan for transverse joints in the lean concrete layer for approval by the RPR.

During production, the Contractor shall submit batch tickets for each delivered load.

EQUIPMENT

306-4.1 All equipment necessary to mix, transport, place, compact, and finish the lean concrete material shall be furnished by the Contractor and is subject to inspection and approval by the RPR. The Contractor shall provide certification that all equipment conforms to the requirements of ASTM C94.

306-4.2 FORMS. Straight side forms shall be made of steel and shall be furnished in sections not less than 10 feet (3 m) in length. Forms shall have a depth equal to the pavement thickness at the edge. Flexible or curved forms of proper radius shall be used for curves of 100 feet (30 m) radius or less. Forms shall be
provided with adequate devices for secure settings so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms with battered top surfaces and bent, twisted or broken forms shall not be used. Built-up forms shall not be used, except as approved by the RPR. The forms shall contain provisions for locking the ends of abutting sections together tightly for secure setting. Wood forms may be used under special conditions, when accepted by the RPR.

306-4.3 CONCRETE PAVERS. A fixed form or slip-form concrete paver may be used to place lean concrete. The paver shall be fully energized, self-propelled and capable of spreading, consolidating, and finishing the lean concrete material, true to grade, tolerances, and cross-sections. The paver shall be of sufficient weight and power to construct the maximum specified concrete paving lane width, at adequate forward speed, without transverse, longitudinal or vertical instability or without displacement. Slip-form pavers shall be equipped with electronic or hydraulic horizontal and vertical control devices. Bridge deck pavers are approved as paver-finishing machines for lean concrete, provided they are capable of handling the amount of lean concrete required for the full-lane width specified, and capable of spreading, consolidating, and finishing the lean concrete material, true to grade, tolerances, and cross-sections.

306-4.4 VIBRATORS. For fixed-form construction, vibrators may be either the surface pan type or internal type with either immersed tube or multiple spuds for the full width of the slab. They may be attached to the spreader, the finishing machine, or mounted on a separate carriage. They shall not come in contact with the subgrade or forms.

For slip-form construction, the paver shall be accomplished by internal vibrators for the full width and depth of the pavement being placed. The number, spacing, frequency, and eccentric weights of vibrators shall be provided to achieve acceptable consolidation without segregation and finishing quality. Internal vibrators may be supplemented by vibrating screeds operating on the surface of the lean concrete. Vibrators and screeds shall automatically stop operation when forward motion ceases. An override switch shall be provided. Handheld vibrators may be used in irregular areas.

306-4.5 JOINT SAWS. The Contractor shall provide a sufficient number of saws with adequate power to cut contraction or construction joints to the required dimensions as shown on the plans. The Contractor shall provide at least one standby saw in good working order.

CONSTRUCTION METHODS

306-5.1 CONTROL STRIP. The first half-day of construction shall be considered the control strip. The Contractor shall demonstrate, in the presence of the RPR, that the materials, equipment, and construction processes meet the requirements of the specification. Control strips that do not meet specification requirements shall be removed and replaced at the Contractor’s expense. Full operations shall not continue until the control strip has been accepted by the RPR. Upon acceptance of the control strip by the RPR, the Contractor shall use the same equipment, materials, and construction methods for the remainder of construction, unless adjustments made by the Contractor are approved in advance by the RPR.

306-5.2 WEATHER LIMITATIONS. The Contractor shall follow the recommended practices in American Concrete Institute (ACI) 306R, Guide to Cold Weather Concreting. The temperature of the mixed lean concrete shall not be less than 50°F (10°C) at the time of placement. The lean concrete shall not be placed when the ambient temperature is below 40°F (4°C) or when conditions indicate that the temperature may fall below 35°F (2°C) within 24 hours. The lean concrete shall not be placed on frozen underlying courses.

The Contractor shall follow the recommended practices in ACI 305R, Guide to Hot Weather Concreting. The lean concrete temperature from initial mixing through final cure shall not exceed 90°F (32°C). When the maximum daily air temperature exceeds 85°F (30°C), the forms and/or the underlying material shall be sprinkled with water before placing the lean concrete.
The Contractor should stop operations prior to and during rain allowing time to cover and protect any plastic lean concrete. Areas damaged by rain shall be refinished or replaced at the Contractor’s expense.

306-5.3 MAINTENANCE. The Contractor shall protect the lean concrete from environmental or mechanical damage. Traffic shall not be allowed on the pavement until test specimens made per ASTM C31 have attained a compressive strength of 500 psi (3445 kPa) when tested per ASTM C39. The Contractor shall maintain continuity of the applied curing method for the entire curing period.

306-5.4 FORM SETTING. Form sections shall be tightly locked and shall be free from play or movement in any direction. The forms shall not deviate from true line by more than 1/4 inch (6 mm) at any joint. The top face of the form shall not vary from a true plane more than 1/8 inch (3 mm) in 10 feet (3 m), and the upstanding leg shall not vary more than 1/4 inch (6 mm). Forms shall be cleaned and oiled prior to the placing of lean concrete.

306-5.5 PREPARATION OF UNDERLYING COURSE. The underlying course shall be checked and accepted by the RPR before placing operations begin. Prior to placing the material, the final grade should be firm, moist and free of frost. Use of chemicals to eliminate frost will not be permitted. The underlying course shall be wetted in advance of placing the lean concrete base course.

306-5.6 GRADE CONTROL. Grade control shall be as necessary to construct the layer to the profile and cross-sections as shown on the plans.

306-5.7 MIXING. The batch plant site, layout, equipment, and provisions for transporting material shall assure a continuous supply of material to the work. Stockpiles shall be constructed in a manner that prevents segregation and intermixing of deleterious materials. All lean concrete shall be mixed and delivered to the site per the requirements of ASTM C94. The mixing time should be adequate to produce lean concrete that is uniform in appearance, with all ingredients evenly distributed. Mixing time shall be measured from the time all materials are emptied into the drum (provided all the water is added before one-fourth the preset mixing time has elapsed) and continues until the time the discharge chute is opened to deliver the lean concrete.

If mixing in a batch plant, the mixing time shall not be less than 50 or greater than 90 seconds. If mixing in a truck mixer, the mixing time shall not be less than 70 or more than 125 truck-drum revolutions at a mixing speed of not less than six (6) or more than 18 truck-drum revolutions per minute.

The elapsed time from the addition of cementitious material to the mix until the lean concrete is deposited in place at the work site shall not exceed 45 minutes when the concrete is hauled in non-agitating trucks, or 90 minutes when it is hauled in truck mixers or truck agitators.

Re-tempering lean concrete will not be permitted, except when delivered in truck mixers. With truck mixers, additional water may be added to the batch materials if the addition of water is added within 45 minutes after the initial mixing operations and the water/cement ratio specified in the mix design is not exceeded.

306-5.8 PLACING. The lean concrete material shall be placed continuously at a uniform rate on the underlying course minimizing segregation and handling of the mix. Rakes shall not be allowed for spreading the lean concrete.

306-5.9 FINISHING. Shape the finished surface of the lean concrete base layer to the specified lines, grades, and cross-section. Hand finishing will not be permitted except in areas where the mechanical finisher cannot operate.

The surface of the lean concrete shall not be textured.

306-5.10 CONSTRUCTION LIMITATIONS. All placement and finishing operations shall be completed within two (2) hours from the start of mixing. Material not completed within the 2-hour time limit shall be removed and replaced at the Contractor’s expense.
At the end of each day’s construction and/or when operations are interrupted for more than 30 minutes, a straight transverse construction joint shall be formed by a header or by cutting back into the compacted material to form a true vertical face.

Completed portions may be opened to light traffic when it has achieved its 7-day strength and the curing is not damaged.

306-5.11 JOINTS. Locate all longitudinal and transverse construction joints as shown on the plans. Longitudinal joints shall be within 6 inches (150 mm) of planned joints in the overlaying concrete pavement and transverse joints shall be within 3 inches (75 mm) the planned joints of the overlying concrete surface. Joints shall be sawn as soon as the base can support the saws without damage to the lean concrete base. Joints shall be constructed by sawing the hardened lean concrete to a depth of at least one-third the thickness of the lean concrete base, or 1/5th the depth of the lean concrete base when constructed using early entry saws.

306-5.12 CURING. Immediately after the finishing operations are complete and within two (2) hours of placement of the lean concrete, the entire surface and edges of the newly placed lean concrete shall be sprayed uniformly with white pigmented, liquid membrane forming curing compound conforming to ASTM C309, Type 2, Class B or clear or translucent Type 1-D, Class B with white fugitive dye in accordance with paragraph 306-2.7. The layer should be kept moist using a moisture-retaining cover or a light application of water until the curing material is applied. The curing compound shall not be applied during rainfall. The curing material shall be applied at a maximum coverage of 200 square feet per gallon (5.0 m²/l) using pressurized mechanical sprayers. The spraying equipment shall be a fully atomizing type equipped with a tank agitator. At the time of use, the curing compound in the tank shall be thoroughly and uniformly mixed with the pigment. During application, the curing compound shall be continuously stirred by mechanical means. Edges of the lean concrete layer shall be sprayed with curing compound immediately following placement with slip-form pavers or when side-forms are removed. Hand spraying of odd widths or shapes and lean concrete surfaces exposed by the removal of forms is permitted.

The lean concrete temperature during curing shall be in accordance with paragraph 306-5.2.

If the curing material becomes damaged from any cause, including sawing operations, within the required 7-day curing period or until the overlying course is constructed, the Contractor shall immediately repair the damaged areas by application of additional curing compound or other means approved by the RPR.

306-5.13 SURFACE TOLERANCE. The Contractor shall perform smoothness and grade checks daily. Any area not meeting smoothness and grade shall be corrected by the Contractor at the Contractor’s expense. The Contractor shall provide smoothness and grade data to the RPR on a daily basis.

a. Smoothness. The finished surface shall not vary more than ±3/8-inch (9 mm) when tested with a 12-foot (3.7-m) straightedge applied parallel with and at right angles to the centerline, and moved continuously forward at half the length of the 12-foot (3.7-m) straightedge for the full length of each line on a 50-foot (15-m) grid. The Contractor shall correct any high spots more than 3/8 inch (9 mm) in 12-foot (3.7-m) with a grinding machine or remove and replace the material at the Contractor’s expense. Any areas that have been ground shall have curing compound reapplied.

b. Grade. The grade shall be measured on a 50-foot (15-m) grid and shall be within +/-0.05 feet (15 mm) of the specified grade. When the surface is more than 1/2 inch (12 mm) above the grade shown in the plans, the surface shall be corrected at the Contractor’s expense to an elevation that falls within a tolerance of 1/4 inch (6 mm).

306-5.14 BOND-BREAKER. Fabric per paragraph 306-2.8 shall be placed on the surface of the lean concrete to prevent bonding. The fabric shall be placed in accordance with Item P-314.
MATERIAL ACCEPTANCE

306-6.1 Sampling and Testing. Acceptance sampling and testing to determine conformance with the requirements specified in this section will be performed by the RPR for each 1200 square yards (1000 square meters). Sampling locations will be determined by the RPR on a random basis per ASTM D3665.

a. Compressive Strength. One sample of freshly delivered lean concrete will be taken for compressive strength for each 1200 square yards (1000 square meters) in accordance with ASTM C172 and air content tests in accordance with ASTM C231. Two test cylinders will be made and cured from the sample per ASTM C31 and the 7-day compressive strength of each cylinder determined per ASTM C39. The compressive strength will be computed by averaging the two 7-day compressive strengths.

The Contractor shall provide for the initial curing of cylinders in accordance with ASTM C31 during the 24 hours after molding.

b. Thickness. Cores shall be drilled by the Contractor at two different sampling locations for thickness determination for each 1200 square yards (1000 square meters). Thickness will be determined by measuring the depth of core holes and computed by averaging the thickness determination of the two locations.

Core holes shall be filled by the Contractor with lean concrete base or non-shrink grout.

306-6.2 Acceptance.

a. Strength. If the lean concrete fails to meet the minimum compressive strength requirements, the Contractor shall remove and replaced the material at the Contractor's expense.

b. Thickness. If the average thickness is not deficient by more than 1/2 inch (12 mm) from the plan thickness, full payment shall be made. When such measurement is deficient by more than 1/2 inch (12 mm) but less than one inch (25 mm) from the plan thickness, the area represented by the test shall be removed and replaced at the Contractor's expense or shall be permitted to remain in-place at an adjusted payment of 75% of the contract unit price.

METHOD OF MEASUREMENT

306-7.1 The quantity of lean concrete base course will be determined by the number of square yard (m²) of lean concrete actually constructed and accepted by the RPR as complying with the plans and specifications.

BASIS OF PAYMENT

306-8.1 Payment will be incidental to the project bid.

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM International (ASTM)

ASTM C31 Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33 Standard Specification for Concrete Aggregates
ASTM C39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C94 Standard Specification for Ready-Mixed Concrete
ASTM C136 Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregates
ASTM C150 Standard Specification for Portland Cement
ASTM C172 Standard Practice for Sampling Freshly Mixed Concrete
ASTM C173 Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C174 Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
ASTM C192 Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231 Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260 Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C309 Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C494 Standard Specification for Chemical Admixtures for Concrete
ASTM C595 Standard Specification for Blended Hydraulic Cements
ASTM C618 Specification for Coal Fly Ash and Raw and Calcined Natural Pozzolans for Use in Concrete
ASTM C989 Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM C1602 Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete

American Association of State Highway and Transportation Officials (AASHTO)
AASHTO T136 Standard Method of Test for Freezing-and-Thawing Tests of Compacted Soil-Cement Mixtures

American Concrete Institute (ACI)
ACI 305R Guide to Hot Weather Concreting
ACI 306R Guide to Cold Weather Concreting

**END OF ITEM P-306**
ITEM P-310 GEOSYNTHETIC PRODUCTS

DESCRIPTION

310-1.1 This item shall consist of furnishing and placing geosynthetic products such as nonwoven geotextile fabric, structural geogrid, pavement stabilization fabric including a bituminous material, pavement repair grid including a bituminous material, and pavement joint repair fabric including a bituminous material on specified areas in accordance with the requirements of this specification, and shall conform to the dimensions shown on the plans or as directed by the Engineer.

MATERIALS

310-2.1 GENERAL. This specification follows the specification guide for Paving Fabrics as established by ASTM D 4354 unless otherwise defined.

Geosynthetic rolls shall be furnished with suitable wrapping to protect against moisture and extended ultraviolet exposure prior to placement. Each roll shall be labeled to provide product identification sufficient for inventory and quality control purposes. Rolls shall be stored in a manner, which protects them from the elements. If stored outdoors, they shall be elevated and protected with a waterproof cover. The Contractor shall furnish to the Engineer a certified test report from the producer, containing all data required to verify compliance with the specifications listed in the appropriate section.

Physical requirements of geosynthetics for various applications are given in section 310-2.2, Geosynthetic Materials. Unless otherwise stated, all property values represent minimum average roll values (MARV) in the weakest principle direction (i.e., average test results from any sampled roll in a lot sampled for conformance or quality assurance testing shall meet or exceed the minimum values in the Tables). Stated values are for non-critical, non-severe conditions. Lots shall be sampled in accordance with ASTM D 4354.

GEOSYNTHETIC MATERIALS

The Contractor shall submit, to the Engineer, for approval, prior to ordering, the manufacturers certification and installation procedure for each material supplied verifying the material to be used meets the requirements of this specification. Certified test results for each lot produced shall be delivered to the job site prior to use.

a. Geotextile Fabric. The fabric used as a stabilization material between subgrade, subbase, stabilized base, or other base material applications shall be constructed of nonwoven long chain synthetic polymers composed of at least 85 percent of polyolephins, polyesters, and polyamides by weight, shall be resistant to chemical attack, mildew, and rot, and shall meet the following physical requirements:

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<th>Minimum Value</th>
<th>Test Method</th>
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<td>ASTM D 4533</td>
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310-2.3 ASPHALT SEALANT. The material used to impregnate, prime, and seal the paving geotextile fabric, and pavement joint repair fabric, as well as bond it to both the base pavement and overlay, shall be the binder required in specification P-401 or manufacturer recommended product (incidental to various items). The material used to apply the pavement repair grid, as well as bond it to both the base pavement and overlay, shall be the tack coat required and quantified in specification P-603. The Contractor shall furnish the vendor's certified test reports plus a one-quart sample for each carload or equivalent of bitumen shipped to the project. The report shall be delivered to the Engineer before permission is granted for use of the material. The furnishing of the vendor's certified test report for the bituminous material shall be the basis for final acceptance of the material unless the Engineer requires tests run on the sample for conformance with AASHTO M 226.

310-2.4 AGGREGATE. Washed concrete sand may be spread over asphalt saturated fabric to facilitate movement of equipment during construction or to prevent tearing or delamination of the fabric. Hot-mix broadcast in front of construction vehicle tires may also be used to serve this purpose for asphalt overlay projects. Excess quantities shall be removed from the fabric prior to placing the surface course.

CONSTRUCTION METHODS

310-3.1 SURFACE PREPARATION.

a. Geotextile Fabric. The subgrade for placement of stabilization fabric shall be inspected prior to installation of the fabric to insure it is smooth and free of any depressions or bumps which could damage or tear the fabric.

If the geotextile is to be placed on a stabilized base course prior to concrete paving, the surface shall be inspected prior to installation to insure it is free of dirt, water, and vegetation and approved by the Engineer. The surface for placement of geotextile shall be free of all foreign material, which could damage or tear the fabric. Any cracks or voids in the surface shall be filled with appropriate material prior to placement of fabric in a manner approved by the Engineer.

All necessary grade and smoothness revisions shall be completed and approved prior to installation of geotextile.

310-3.2 WEATHER LIMITATIONS. Neither the asphalt sealant nor fabric shall be placed when weather conditions, in the opinion of the Engineer, are not suitable. Air and pavement temperatures shall be sufficient to allow the asphalt sealant to hold the fabric in place. For asphalt cements, air temperature shall be 50 degrees Fahrenheit and rising.

310-3.3 APPLICATION OF BITUMINOUS MATERIAL. The bituminous material (asphalt binder, primer, or tack coat) shall be uniformly spray applied to the prepared dry pavement surface at the specified rate. The quantity specified will vary with the surface conditions but will normally be applied at the rate of 0.25 to 0.3 gallons per square yard per square yard of nonwoven fabric (pavement stabilization fabric, concrete bond breaker) and at a rate of .05 to .15 gallons per square yard for pavement repair grids, or as directed by the manufacturer of the material and approved by the Engineer.

Application of the bituminous material shall be by distributor spray bar, with hand spraying kept to a minimum. Temperature of the asphalt binder shall be sufficiently high to permit a uniform spray pattern. For asphalt cements, the minimum temperature shall be 290 degrees Fahrenheit. To avoid damage to the fabric, however, the distributor tank temperature shall not exceed 325 degrees Fahrenheit. The width of asphalt sealant shall be the width of the fabric plus six inches. The asphalt sealant shall not be applied any farther in advance of fabric or grid placement than the distance which the Contractor can maintain
free of traffic. All asphalt spills shall be cleaned thoroughly from the pavement surface to avoid flushing and fabric movement. The rate of application for pavement stabilization shall be sufficient to satisfy the asphalt retention properties of the fabric and bond the fabric and overlay to the old pavement.

310-3.4 FABRIC PLACEMENT.

a. Geotextile Fabric. Overlap of fabric joints shall be sufficient to ensure full closure of the joint, but should not be less than one (1) foot. Transverse joints shall be lapped a minimum of one (1) foot in the direction of the grading of the next course of subbase or base. Care shall be taken in placing the first layer of material on the stabilization fabric so to not displace the lapped joint.

Overlay of fabric joints shall be as recommended by the manufacturer but not less than one foot.

Should the geotextile fabric be placed directly beneath concrete pavement on stabilized base course the following requirements apply:

1. The fabric shall be placed into the asphaltic sealant with a minimum of wrinkles prior to the time the asphalt has cooled and lost tackiness. In the event the asphalt has cooled and lost tackiness, a new film of sealant will be placed. Wrinkles or folds in excess on one (1) inch shall be slit and laid flat. Brooming and/or pneumatic rolling will maximize fabric contact with the underlying surface. The fabric shall be unrolled and placed in accordance with manufacturer's recommendations.

Overlay of fabric joints shall be sufficient to ensure full closure of the joint, but should not be less than two (2) inches or exceed six (6) inches. Transverse joints shall be lapped a minimum of two inches in the direction of paving to prevent edge pickup by the paver.

310-3.5 BITUMINOUS SURFACE COURSE OVERLAY. Placement of the hot-mix overlay should closely follow pavement stabilization fabric or pavement repair grid laydown. The temperature of the mix shall not exceed 325 degrees Fahrenheit. In the event excessive asphalt sealant bleeds through the fabric causing construction problems before the overlay is placed, the affected areas shall be blotted by spreading sand or hot-mix. To avoid movement or damage to the fabric or grid, turning of the paver and other vehicles shall be gradual and kept to a minimum. Any damage resulting from traffic crossing the fabric shall be repaired to the satisfaction of the Engineer, at the Contractors expense. If, in the opinion of the Engineer, the fabric surface appears dry and lacks tackiness a light tack coat shall be applied prior to the overlay.

310-3.6 RIGID PAVEMENT PLACEMENT. Placement of the Portland cement concrete pavement over nonwoven geotextile fabric should closely follow the fabric laydown. In the event excessive asphalt sealant, when required, bleeds through the fabric before the pavement is placed, it may be necessary to blot the sealant by spreading sand over the affected areas. Blotting will prevent any tendency for construction equipment to pick up the fabric when driving over it. To avoid movement or damage to the fabric, turning of the slip-form paver and other vehicles shall be gradual and kept to a minimum. Damage to the fabric shall be replaced by the Contractor at his own expense. The Portland cement concrete shall be placed in accordance with P-501.
METHOD OF MEASUREMENT

310-4.1 Geotextile Fabric shall be measured by the number of square yards of area covered measured in its final position. Pay quantities will be computed to the neat lines staked by the Contractor in accordance with the plans or as directed by the Engineer. Measurement will not include the lapping of transverse or longitudinal joints, wrapped material associated with edge anchoring nor material required to construct underdrains.

BASIS OF PAYMENT

310-5.1 Payment shall be incidental to the project bid.

TESTING AND MATERIAL REQUIREMENTS

- ASTM D-276 Identification of Fibers in Textiles
- ASTM D-4632 Breaking Load and Elongation of Geotextiles (Grab Method)
- ASTM-3786 Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabrics
- ASTM-3786 Bursting Strength of Knitted Goods
- ASTM-D 4354 Sampling of Geotextiles for Testing
- ASTM D 4355 Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus)
- ASTM D 4595 Tensile Properties of Geotextiles by the Wide-Width Strip Method (Modified per GSI GRI GG6 for Geogrid)
- ASTM D 4873 Identification, Storage, and Handling of Geosynthetic Rolls
- ASTM D 5262 Evaluating the Unconfined Tension Creep Behavior of Geosynthetics
- ASTM D 5321 Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method
- AASHTO M-226 Viscosity Graded Asphalt Cement
- GSI GRI GG1 (1988) Geogrid Rib Tensile Strength
- GSI GRI GG4a Determination of the Long-Term Design Strength of Stiff Geogrids
- GSI GRI GG4b Determination of the Long-Term Design Strength of Flexible Geogrids
- GSI GRI GG5 Geogrid Pullout
- GSI GRI GG6 Grip Types for Use in the Wide Width Testing of Geotextiles and Geogrids
- Texas D.O.T. 3099 Asphalt Retention

**END OF ITEM P-310**
ITEM P-314 BOND BREAKER FABRIC

DESCRIPTION

314-1.1 This item shall consist of furnishing and installing a bond breaker fabric in the construction areas as shown on the plans.

MATERIALS

314-2.1 Bond Breaker Fabric shall be a needle-punched nonwoven geotextile composed of polypropylene fibers conforming to the following test methods and physical properties.

<table>
<thead>
<tr>
<th>Mechanical Properties</th>
<th>Test Method</th>
<th>Units</th>
<th>Roll Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass per Unit Area</td>
<td>ASTM D 5261</td>
<td>oz/yd²</td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td></td>
<td></td>
<td>13.3</td>
</tr>
<tr>
<td>Maximum</td>
<td></td>
<td></td>
<td>16.2</td>
</tr>
<tr>
<td>Thickness Under Load</td>
<td>ASTM D 5199</td>
<td>mm</td>
<td></td>
</tr>
<tr>
<td>0.29 psi</td>
<td></td>
<td></td>
<td>3.0 min</td>
</tr>
<tr>
<td>2.9 psi</td>
<td></td>
<td></td>
<td>2.5 min</td>
</tr>
<tr>
<td>29 psi</td>
<td></td>
<td></td>
<td>1.0 min</td>
</tr>
<tr>
<td>Wide Width Tensile Strength</td>
<td>ASTM D 4595</td>
<td>lbs/ft</td>
<td>684 min</td>
</tr>
<tr>
<td>Wide Width Elongation</td>
<td>ASTM D 4595</td>
<td>%</td>
<td>130 max</td>
</tr>
<tr>
<td>Water Permeability in Normal Direction under load</td>
<td>ASTM D 5493</td>
<td>m/s</td>
<td>1 x 10⁻⁴ min</td>
</tr>
<tr>
<td>2.9 psi (20 kPa)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-plane Water Permeability</td>
<td>ASTM D 6574</td>
<td>m/s</td>
<td>5 x 10⁻⁴ min</td>
</tr>
<tr>
<td>29 psi (200 kPa)</td>
<td></td>
<td>m/s</td>
<td>2 x 10⁻⁴ min</td>
</tr>
<tr>
<td>Alkali Resistance</td>
<td>EN 13249</td>
<td>%</td>
<td>96 min</td>
</tr>
<tr>
<td>UV Resistance (at 500 hours)</td>
<td>ASTM D 4355</td>
<td>% Strength Retained</td>
<td>60 min</td>
</tr>
</tbody>
</table>

Alternate bond breaker materials will be evaluated provided that a submittal is provided two weeks prior to the bid. The alternate bond breaker submittal must include a design signed and sealed by a professional engineer registered to practice in the country, state or province in which the project is located and a list of at least 5 projects where the product has been in ground for over a year under similar environmental conditions in which performance can be documented.
STORAGE

314-3.1 Bond breaker rolls shall be furnished with suitable wrapping to protect against moisture and extended ultraviolet exposure prior to placement.

314-3.2 Each roll shall be tagged or labeled with the name of the product and manufacturer. All rolls shall be tagged or labeled with the width, length, and unique roll number for quality tracking purposes. The tag or label shall be securely fastened to the outside of the roll.

314-3.3 Rolls shall be stored and handled in a manner to prevent damage.

314-3.4 After unloading, inspect rolls for defects and damage.

314-3.5 Bond breaker shall be stored per manufacturer’s recommendations in a dry covered condition, free from dust, dirt and moisture.

314.3.6 Rolls shall be stored off ground, protected from precipitation, ultraviolet radiation, strong chemicals, sparks and flames, temperatures in excess of 71 °C (160 °F) and other environmental condition that could cause damage to bond breaker.

CONSTRUCTION METHODS

314-4.1 BASE COURSE PREPARATION

a. Before installing fabric, all base course materials must be accepted for grade, and approved by the engineer for installation of fabric.

314-4.2 BOND BREAKER FABRIC INSTALLATION

a. In areas which will exposed to traffic, fabric shall not be installed until immediately prior to paving operations. But in no case shall fabric be installed more than 3 days prior to paving operations.

b. Bond Breaker Fabric shall be secured to underlying layer with pins or nails punched through 2 to 2.75-inch galvanized washers or discs every 6 feet or less. Additional fasteners can be used as needed to ensure that the fabric does not shift or fold before or during concrete placement.

c. Where it occurs, edges of the fabric shall overlap by 12 inches, minimum.

314-4.3 CONCRETE OVERLAY

The concrete overlay shall be constructed per the requirements of P-501, and will be paid under that item.

METHOD OF MEASUREMENT

314-5.1 Bond Breaker Fabric shall be measured by the number of square yards of area covered measured in its final position. Pay quantities will be computed to the neat lines staked by the Contractor in accordance with the plans or as directed by the Engineer. Measurement will not include the lapping of transverse or longitudinal joints.
BASIS OF PAYMENT

314-6.1 Payment shall be incidental to the project bid.

**END OF ITEM P-314**
ITEM P-605 JOINT SEALANTS FOR PAVEMENTS

DESCRIPTION

605-1.1 This item shall consist of providing and installing a resilient and adhesive joint sealing material capable of effectively sealing joints in pavement; joints between different types of pavements; and cracks in existing pavement.

MATERIALS

605-2.1 JOINT SEALANTS. Joint sealant materials shall meet the requirements of ASTM D5893 Standard Specifications for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements.

Each lot or batch of sealant shall be delivered to the jobsite in the manufacturer’s original sealed container. Each container shall be marked with the manufacturer’s name, batch or lot number, the safe heating temperature, and shall be accompanied by the manufacturer’s certification stating that the sealant meets the requirements of this specification.

605-2.2 BACKER ROD. The material furnished shall be a compressible, non-shrinking, non-staining, non-absorbing material that is non-reactive with the joint sealant in accordance with ASTM D5249.

The backer-rod material shall be 25% ± 5 % larger in diameter than the nominal width of the joint.

605-2.3 BOND BREAKING TAPES. Provide a bond breaking tape or separating material that is a flexible, non-shrinkable, non-absorbing, non-staining, and non-reacting adhesive-backed tape. The material shall have a melting point at least 5°F (3°C) greater than the pouring temperature of the sealant being used when tested in accordance with ASTM D789. The bond breaker tape shall be approximately 1/8 inch (3 mm) wider than the nominal width of the joint and shall not bond to the joint sealant.

CONSTRUCTION METHODS

605-3.1 TIME OF APPLICATION. Joints shall be sealed as soon after completion of the curing period as feasible and before the pavement is opened to traffic, including construction equipment. The pavement temperature shall be 50°F (10°C) and rising at the time of application of the poured joint sealing material. Do not apply sealant if moisture is observed in the joint.

605-3.2 EQUIPMENT. Machines, tools, and equipment used in the performance of the work required by this section shall be approved before the work is started and maintained in satisfactory condition at all times. Submit a list of proposed equipment to be used in performance of construction work including descriptive data, 30 days prior to use on the project.

b. Concrete saw. Provide a self-propelled power saw, with water-cooled diamond or abrasive saw blades, for cutting joints to the depths and widths specified.

c. Sandblasting equipment. The Contractor must demonstrate sandblasting equipment including the air compressor, hose, guide and nozzle size, under job conditions, before approval in accordance with paragraph 605-3.3. The Contractor shall demonstrate, in the presence of the Resident Project Representative (RPR), that the method cleans the joint and does not damage the joint.

d. Water blasting equipment. The Contractor must demonstrate water blasting equipment including the pumps, hose, guide and nozzle size, under job conditions, before approval in
accordance with paragraph 605-3.3. The Contractor shall demonstrate, in the presence of the RPR, that the method cleans the joint and does not damage the joint.

e. **Hand tools.** Hand tools may be used, when approved, for removing defective sealant from a crack and repairing or cleaning the crack faces. Hand tools should be carefully evaluated for potential spalling effects prior to approval for use.

f. **Hot-poured sealing equipment.** The unit applicators used for heating and installing ASTM D6690 joint sealant materials shall be mobile and shall be equipped with a double-boiler, agitator-type kettle with an oil medium in the outer space for heat transfer; a direct-connected pressure-type extruding device with a nozzle shaped for inserting in the joint to be filled; positive temperature devices for controlling the temperature of the transfer oil and sealant; and a recording type thermometer for indicating the temperature of the sealant. The applicator unit shall be designed so that the sealant will circulate through the delivery hose and return to the inner kettle when not in use.

g. **Cold-applied, single-component sealing equipment.** The equipment for installing ASTM D5893 single component joint sealants shall consist of an extrusion pump, air compressor, following plate, hoses, and nozzle for transferring the sealant from the storage container into the joint opening. The dimension of the nozzle shall be such that the tip of the nozzle will extend into the joint to allow sealing from the bottom of the joint to the top. Maintain the initially approved equipment in good working condition, serviced in accordance with the supplier’s instructions, and unaltered in any way without obtaining prior approval. Small hand-held air-powered equipment (i.e., caulking guns) may be used for small applications.

**605-3.3 PREPARATION OF JOINTS.** Pavement joints for application of material in this specification must be dry, clean of all scale, dirt, dust, curing compound, and other foreign matter. The Contractor shall demonstrate, in the presence of the RPR, that the method cleans the joint and does not damage the joint.

a. **Sawing.** All joints shall be sawed in accordance with specifications and plan details. Immediately after sawing the joint, the resulting slurry shall be completely removed from joint and adjacent area by flushing with a jet of water, and by use of other tools as necessary.

b. **Sealing.** Immediately before sealing, the joints shall be thoroughly cleaned of all remaining laitance, curing compound, filler, protrusions of hardened concrete, old sealant and other foreign material from the sides and upper edges of the joint space to be sealed. Cleaning shall be accomplished by sandblasting, concrete saw or water blaster as specified in paragraph 605-3.2. The newly exposed concrete joint faces and the pavement surface extending a minimum of 1/2 inch (12 mm) from the joint edge shall be sandblasted clean. Sandblasting shall be accomplished in a minimum of two passes. One pass per joint face with the nozzle held at an angle directly toward the joint face and not more than 3 inches (75 mm) from it. After final cleaning and immediately prior to sealing, blow out the joints with compressed air and leave them completely free of debris and water. The joint faces shall be surface dry when the seal is applied.

c. **Backer Rod.** When the joint opening is of a greater depth than indicated for the sealant depth, plug or seal off the lower portion of the joint opening using a backer rod in accordance with paragraph 605-2.2 to prevent the entrance of the sealant below the specified depth. Take care to ensure that the backer rod is placed at the specified depth and is not stretched or twisted during installation.

d. **Bond-breaking tape.** Where inserts or filler materials contain bitumen, or the depth of the joint opening does not allow for the use of a backup material, insert a bond-separating tape breaker in accordance with paragraph 605-2.3 to prevent incompatibility with the filler materials and three-sided adhesion of the sealant. Securely bond the tape to the bottom of the joint opening so it will not float up into the new sealant.
605-3.4 INSTALLATION OF SEALANTS. Joints shall be inspected for proper width, depth, alignment, and preparation, and shall be approved by the RPR before sealing is allowed. Sealants shall be installed in accordance with the following requirements:

Immediately preceding, but not more than 50 feet (15 m) ahead of the joint sealing operations, perform a final cleaning with compressed air. Fill the joints from the bottom up to 1/4 inch (6 mm) ±1/16 inch (2 mm) below the top of pavement surface; or bottom of groove for grooved pavement. Remove and discard excess or spalled sealant from the pavement by approved methods. Install the sealant in such a manner as to prevent the formation of voids and entrapped air. In no case shall gravity methods or pouring pots be used to install the sealant material. Traffic shall not be permitted over newly sealed pavement until authorized by the RPR. When a primer is recommended by the manufacturer, apply it evenly to the joint faces in accordance with the manufacturer’s instructions. Check the joints frequently to ensure that the newly installed sealant is cured to a tack-free condition within the time specified.

605-3.5 INSPECTION. The Contractor shall inspect the joint sealant for proper rate of cure and set, bonding to the joint walls, cohesive separation within the sealant, reversion to liquid, entrapped air and voids. Sealants exhibiting any of these deficiencies at any time prior to the final acceptance of the project shall be removed from the joint, wasted, and replaced as specified at no additional cost to the airport.

605-3.6 CLEAN-UP. Upon completion of the project, remove all unused materials from the site and leave the pavement in a clean condition.

METHOD OF MEASUREMENT

605-4.1 No measurement will be made of joint sealing materials required in the construction of concrete pavements or structures. The cost of furnishing and installing joint materials shall be included in the Contractor’s price for pavements and structures.

BASIS OF PAYMENT

605-5.1 No separate payment will be made for sawing or joint sealing.

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM International (ASTM)

ASTM D789 Standard Test Method for Determination of Relative Viscosity of Polyamide (PA)


Advisory Circulars (AC)

AC 150/5340-30 Design and Installation Details for Airport Visual Aids

**END ITEM P-605**
ITEM F-162 CHAIN-LINK FENCE

DESCRIPTION
162-1.1 This item shall consist of furnishing and erecting a chain-link fence in accordance with these specifications, the details shown on the plans, and in conformity with the lines and grades shown on the plans or established by the RPR.

MATERIALS
162-2.1 FABRIC. The fabric shall be woven with a 9-gauge galvanized steel wire in a 2-inch (50 mm) mesh and shall meet the requirements of ASTM A392.

162-2.2 BARBED WIRE. Barbed wire shall be 2-strand 12-1/2 gauge zinc-coated wire with 4-point barbs and shall conform to the requirements of ASTM A 121, Class 3, Chain Link Fence Grade.

162-2.3 POSTS, RAILS, AND BRACES. Line posts, rails, and braces shall conform to the requirements of ASTM F1043 or ASTM F1083 as follows:

- Galvanized tubular steel pipe shall conform to the requirements of Group IA, (Schedule 40) coatings conforming to Type A, or Group IC (High Strength Pipe), External coating Type B, and internal coating Type B or D.
- Roll Formed Steel Shapes (C-Sections) shall conform to the requirements of Group IIA, and be galvanized in accordance with the requirements of ASTM F1043, Type A.
- Hot-Rolled Shapes (H Beams) shall meet the requirements of Group III, and be galvanized in accordance with the requirements of ASTM F1043, Type A.
- Aluminum Pipe shall conform to the requirements of Group IB.
- Aluminum Shapes shall conform to the requirements of Group IIB.
- Vinyl or polyester coated steel shall conform to the requirements of ASTM F1043, Paragraph 7.3, Optional Supplemental Color Coating.
- Composite posts shall conform to the strength requirements of ASTM F1043 or ASTM F1083. The strength loss of composite posts shall not exceed 10% when subjected to 3,600 hours of exposure to light and water in accordance with ASTM G152, ASTM G153, ASTM G154, and ASTM G155.
- Posts, rails, and braces furnished for use in conjunction with aluminum alloy fabric shall be aluminum alloy or composite.
Posts, rails, and braces, with the exception of galvanized steel conforming to ASTM F1043 or ASTM F1083, Group 1A, Type A, or aluminum alloy, shall demonstrate the ability to withstand testing in salt spray in accordance with ASTM B117 as follows:

- External: 1,000 hours with a maximum of 5% red rust.
- Internal: 650 hours with a maximum of 5% red rust.

The dimensions of the posts, rails, and braces shall be in accordance with Tables I through VI of Federal Specification RR-F-191/3.

162-2.4 GATES. Gate frames shall consist of galvanized steel pipe or aluminum alloy pipe and shall conform to the specifications for the same material under paragraph 162-2.3. The fabric shall be of the same type material as used in the fence.

162-2.5 WIRE TIES AND TENSION WIRES. Wire ties for use in conjunction with a given type of fabric shall be of the same material and coating weight identified with the fabric type. Tension wire shall be 7-gauge marcelled steel wire with the same coating as the fabric type and shall conform to ASTM A824.

All material shall conform to Federal Specification RR-F-191/4.

162-2.6 MISCELLANEOUS FITTINGS AND HARDWARE. Miscellaneous steel fittings and hardware for use with zinc-coated steel fabric shall be of commercial grade steel or better quality, wrought or cast as appropriate to the article, and sufficient in strength to provide a balanced design when used in conjunction with fabric posts, and wires of the quality specified herein. All steel fittings and hardware shall be protected with a zinc coating applied in conformance with ASTM A153. Barbed wire support arms shall withstand a load of 250 pounds (113 kg) applied vertically to the outermost end of the arm.

162-2.7 CONCRETE. Concrete shall have a minimum 28-day compressive strength of 3000 psi (2670 kPa).

162-2.8 MARKING. Each roll of fabric shall carry a tag showing the kind of base metal (steel, aluminum, or aluminum alloy number), kind of coating, the gauge of the wire, the length of fencing in the roll, and the name of the manufacturer. Posts, wire, and other fittings shall be identified as to manufacturer, kind of base metal (steel, aluminum, or aluminum alloy number), and kind of coating.
CONSTRUCTION METHODS

162-3.1 GENERAL. The fence shall be constructed in accordance with the details on the plans and as specified here using new materials. All work shall be performed in a workmanlike manner satisfactory to the RPR. The Contractor shall layout the fence line based on the plans. The Contractor shall span the opening below the fence with barbed wire at all locations where it is not practical to conform the fence to the general contour of the ground surface because of natural or manmade features such as drainage ditches. The new fence shall be permanently tied to the terminals of existing fences as shown on the plans. The Contractor shall stake down the woven wire fence at several points between posts as shown on the plans.

The Contractor shall arrange the work so that construction of the new fence will immediately follow the removal of existing fences. The length of unfenced section at any time shall not exceed 300 feet (90 m). The work shall progress in this manner and at the close of the working day the newly constructed fence shall be tied to the existing fence.

162-3.2 CLEARING FENCE LINE. Clearing shall consist of the removal of all stumps, brush, rocks, trees, or other obstructions that will interfere with proper construction of the fence. Stumps within the cleared area of the fence shall be grubbed or excavated. The bottom of the fence shall be placed a uniform distance above ground, as specified in the plans. When shown on the plans or as directed by the RPR, the existing fences which interfere with the new fence location shall be removed by the Contractor as a part of the construction work unless such removal is listed as a separate item in the bid schedule. All holes remaining after post and stump removal shall be refilled with suitable soil, gravel, or other suitable material and compacted with tampers.

The cost of removing and disposing of the material shall not constitute a pay item and shall be considered incidental to fence construction.

162-3.3 INSTALLING POSTS. All posts shall be set in concrete at the required dimension and depth and at the spacing shown on the plans.

The concrete shall be thoroughly compacted around the posts by tamping or vibrating and shall have a smooth finish slightly higher than the ground and sloped to drain away from the posts. All posts shall be set plumb and to the required grade and alignment. No materials shall be installed on the posts, nor shall the posts be disturbed in any manner within seven (7) days after the individual post footing is completed.

Should rock be encountered at a depth less than the planned footing depth, a hole 2 inches (50 mm) larger than the greatest dimension of the posts shall be drilled to a depth of 12 inches (300 mm). After the posts are set, the remainder of the drilled hole shall be filled with grout, composed of one part Portland cement and two parts mortar sand. Any remaining space above the rock shall be filled with concrete in the manner described above.
In lieu of drilling, the rock may be excavated to the required footing depth. No extra compensation shall be made for rock excavation.

162-3.4 INSTALLING TOP RAILS. The top rail shall be continuous and shall pass through the post tops. The coupling used to join the top rail lengths shall allow for expansion.

162-3.5 INSTALLING BRACES. Horizontal brace rails, with diagonal truss rods and turnbuckles, shall be installed at all terminal posts.

162-3.6 INSTALLING FABRIC. The wire fabric shall be firmly attached to the posts and braced as shown on the plans. All wire shall be stretched taut and shall be installed to the required elevations. The fence shall generally follow the contour of the ground, with the bottom of the fence fabric no less than one inch (25 mm) or more than 4 inches (100 mm) from the ground surface. Grading shall be performed where necessary to provide a neat appearance.

At locations of small natural swales or drainage ditches and where it is not practical to have the fence conform to the general contour of the ground surface, longer posts may be used and multiple strands of barbed wire stretched to span the opening below the fence. The vertical clearance between strands of barbed wire shall be 6 inches (150 mm) or less.

162-3.7 ELECTRICAL GROUNDS. Electrical grounds shall be constructed at 500 feet (150 m) intervals. The ground shall be accomplished with a copper clad rod 8 feet (2.4 m) long and a minimum of 5/8 inches (16 mm) in diameter driven vertically until the top is 6 inches (150 mm) below the ground surface. A No. 6 solid copper conductor shall be clamped to the rod and to the fence in such a manner that each element of the fence is grounded. Installation of ground rods shall not constitute a pay item and shall be considered incidental to fence construction. The Contractor shall comply with FAA-STD-019, Lightning and Surge Protection, Grounding, Bonding and Shielding Requirements for Facilities and Electronic Equipment, paragraph 4.2.3.8, Lightning Protection for Fences and Gates, when fencing is adjacent to FAA facilities.

162-3.8 CLEANING UP. The Contractor shall remove from the vicinity of the completed work all tools, buildings, equipment, etc., used during construction. All disturbed areas shall be reseeded if required.
METHOD OF MEASUREMENT

162-4.1 Chain-link fence will be measured for payment by the linear foot (meter). Measurement will be along the top of the fence from center to center of end posts, excluding the length occupied by gate openings.

BASIS OF PAYMENT

162-5.1 Payment for chain-link fence will be made at the contract unit price per linear foot (meter).

162-5.2 Payment for vehicle or pedestrian gates – not applicable.

162-5.3 Payment for removal of existing fence will be made at the contract unit price per linear foot (meter).

The price shall be full compensation for furnishing all materials, and for all preparation, erection, and installation of these materials, and for all labor equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

- Item F-162a 7' Chain-Link Fence with 3 Strands of Barbwire per linear foot (meter)
- Item F-162b Remove and Reinstall Security Fence – per linear foot (meter)

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM International (ASTM)

- ASTM A121 Standard Specification for Metallic-Coated Carbon Steel Barbed Wire
- ASTM A153 Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
- ASTM A392 Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric
- ASTM A491 Standard Specification for Aluminum-Coated Steel Chain-Link Fence Fabric
- ASTM A824 Standard Specification for Metallic-Coated Steel Marcelled Tension Wire for Use with Chain Link Fence
- ASTM B117 Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM F668  Standard Specification for Polyvinyl Chloride (PVC), Polyolefin and other Organic Polymer Coated Steel Chain-Link Fence Fabric
ASTM F1043  Standard Specification for Strength and Protective Coatings on Steel Industrial Fence Framework
ASTM F1083  Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures
ASTM F1183  Standard Specification for Aluminum Alloy Chain Link Fence Fabric
ASTM F1345  Standard Specification for Zinc 5% Aluminum-Mischmetal Alloy Coated Steel Chain-Link Fence Fabric
ASTM G152  Standard Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials
ASTM G154  Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials
ASTM G155  Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Nonmetallic Materials

Federal Specifications (FED SPEC)
FED SPEC RR-F-191/3  Fencing, Wire and Post, Metal (Chain-Link Fence Posts, Top Rails and Braces)
FED SPEC RR-F-191/4  Fencing, Wire and Post, Metal (Chain-Link Fence Accessories)

FAA Standard
FAA-STD-019  Lightning and Surge Protection, Grounding, Bonding and Shielding Requirements for Facilities and Electronic Equipment

FAA Orders
5300.38  AIP Handbook

END OF ITEM F-162