Project Manual

Madison Fire Station 14

City of Madison Fire Department

Bid Documents

Volume 2 of 2

November 3, 2017

Madison Project No. 17451
Madison Contract No. 8027
OPN Project No. 17207000

OPN ARCHITECTS

TABLE OF CONTENTS

VOLUME 1

VOLUME 2

DIVISION 21 – FIRE SUPPRESSION

DIVISION 22 - PLUMBING

DIVISION 23 – HEATING, VENTILATING, AND AIR-CONDITIONING (HVAC)

DIVISION 26 – ELECTRICAL

SECTION 21 05 00
BASIC FIRE SUPPRESSION REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Requirements applicable to all Division 21 Sections. Also refer to Division 1 - General Requirements.

B. All materials and installation methods shall conform to the applicable standards, guidelines and codes referenced in the specification section.

1.2 SCOPE OF WORK

A. This Specification and the associated drawings govern the furnishing, installing, testing and placing into satisfactory operation the Mechanical Systems.

B. Each Contractor shall provide all new materials indicated on the drawings and/or in these specifications, and all items required to make his portion of the Mechanical Work a finished and working system.

C. All work will be awarded under a single General Contract.

1.3 DIVISION OF WORK BETWEEN MECHANICAL, ELECTRICAL & CONTROL CONTRACTORS

A. Definitions:

1. "Mechanical Contractors" refers to the following:

   a. Plumbing Contractor.
   b. Heating Contractor.
   c. Air Conditioning and Ventilating Contractor.
   d. Temperature Control Contractor.
   e. Fire Protection Contractor.
   f. Testing, Adjusting, and Balancing Contractor.

2. Motor Control Wiring: The wiring associated with the remote operation of the magnetic coils of magnetic motor starters or relays, or the wiring that permits direct cycling of motors by means of devices in series with the motor power wiring. In the latter case the devices are usually single phase and are usually connected to the motor power wiring through a manual motor starter having "Manual-Off-Auto" provisions.

3. Control devices such as start-stop push buttons, thermostats, pressure switches, flow switches, relays, etc., generally represent the types of equipment associated with motor control wiring.

4. Motor control wiring is single phase and usually 120 volts. In some instances, the voltage will be the same as the motor power wiring. Generally, where the motor power wiring exceeds 120 volts, a control transformer is used to give a control voltage of 120 volts.

5. Temperature Control Wiring: The wiring associated with the operation of a motorized damper, solenoid valve or motorized valve, etc., either modulating or two-position, as opposed to wiring which directly powers or controls a motor used to drive equipment such as fans, pumps, etc.

   a. This wiring will be from a 120 volt source and may continue as 120 volt, or be reduced in voltage (24 volt) in which case a control transformer shall be furnished as part of the temperature control wiring.

6. Control Motor: An electric device used to operate dampers, valves, etc. It may be two-position or modulating. Conventional characteristics of such a motor are 24 volts, 60 cycles, 1 phase, although other voltages may be encountered.

B. General:

1. The purpose of these Specifications is to outline the Electrical and Mechanical Contractor's responsibilities related to electrical work required for items such as temperature controls, mechanical equipment, fans, chillers, compressors and the like. The exact wiring requirements for much of the equipment cannot be determined until the systems have been selected and submittals reviewed. Therefore, the electrical drawings show only known wiring related to such items. All wiring not shown on the electrical drawings, but required for mechanical systems, is the responsibility of the Mechanical Contractor.

2. Where the drawings require the Electrical Contractor to wire between equipment furnished by the Mechanical Contractor, such wiring shall terminate at terminals provided in the equipment. The Mechanical Contractor shall provide complete wiring diagrams and supervision to the Electrical Contractor and designate the terminal numbers for correct wiring.

3. All electrical work shall conform to the National Electrical Code. All provisions of the Electrical Specifications concerning wiring, protection, etc., apply to wiring provided by the Mechanical Contractor unless noted otherwise.

C. Mechanical Contractor's Responsibility:

1. Assumes responsibility for internal wiring of all equipment provided by the Mechanical Contractor, for example:

   a. Burners.
   b. Condensing Units.
   c. Makeup Air Units.
   d. Gas Trains.
   e. Air Handling Units.

2. Assumes all responsibility for the Temperature Control wiring, when the Temperature Control Contractor is a Subcontractor to the Mechanical Contractor.

3. Temperature Control Subcontractor's Responsibility:

   a. Wiring of all devices needed to make the Temperature Control System functional.

   b. Verifying any control wiring on the electrical drawings as being by the Electrical Contractor. All wiring required for the Control System, but not shown on the electrical drawings, is the responsibility of the Temperature Control Subcontractor.

   c. Coordinating equipment locations (such as relays, transformers, etc.) with the Electrical Contractor, where wiring of the equipment is by the Electrical Contractor.

4. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

D. Electrical Contractor's Responsibility:

1. Provides all combination starters, manual starters and disconnect devices shown on the Electrical Drawings or indicated to be by the Electrical Contractor on the Mechanical Drawings or Specifications.

2. Installs and wires all remote control devices furnished by the Mechanical Contractor or Temperature Control Subcontractor when so noted on the Electrical Drawings.

3. Provides motor control and temperature control wiring, where so noted on the drawings.

4. Furnishes, installs and connects all relays, etc., for automatic shutdown of certain fans upon actuation of the Fire Alarm System as indicated and specified in Division 28.

5. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

1.4 COORDINATION DRAWINGS

A. Definitions:

1. Coordination Drawings: A compilation of the pertinent layout and system drawings that show the sizes and locations, including elevations, of system components and required access areas to ensure that no two objects will occupy the same space.

a. Mechanical trades shall include, but are not limited to, mechanical equipment, ductwork, fire protection systems, plumbing piping, hydronic piping, and any item that may impact coordination with other disciplines.

b. Electrical trades shall include, but are not limited to, electrical equipment, conduit 1.5" and larger, conduit racks, cable trays, pull boxes, transformers, raceway, busway, lighting, ceiling-mounted devices, and any item that may impact coordination with other disciplines.

c. Technology trades shall include, but are not limited to, technology equipment, racks, conduit 1.5" and larger, conduit racks, cable trays, ladder rack, pull boxes, raceway, ceiling-mounted devices, and any item that may impact coordination with other disciplines.

d. Maintenance clearances and code-required dedicated space shall be included.

e. The coordination drawings shall include all underground, underfloor, in-floor, in chase, and vertical trade items.

2. The contractors shall use the coordination process to identify the proper sequence of installation of all utilities above ceilings and in other congested areas, to ensure an orderly and coordinated end result, and to provide adequate access for service and maintenance.

B. Participation:

1. The contractors and subcontractors responsible for work defined above shall participate in the coordination drawing process.

2. One contractor shall be designated as the Coordinating Contractor for purposes of preparing a complete set of composite electronic CAD coordination drawings that include all applicable trades, and for coordinating the activities related to this process. The Coordinating Contractor for this project shall be the HVAC Contractor.

a. The Coordinating Contractor shall utilize personnel familiar with requirements of this project and skilled as draftspersons/CAD operators, competent to prepare the required coordination drawings.

3. Electronic CAD drawings shall be submitted to the Coordinating Contractor for addition of work by other trades. KJWW will provide electronic file copies of ventilation drawings for contractor's use if the contractor signs and returns an "Electronic File Transfer" waiver provided by KJWW. KJWW will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings.

C. General:

1. Coordination drawing files shall be made available to the A/E and Owner's Representative. The A/E will only review identified conflicts and give an opinion, but will not perform as a coordinator.

2. A plotted set of coordination drawings shall be available at the project site.

3. Coordination drawings are not shop drawings and shall not be submitted as such.

4. The contract drawings are schematic in nature and do not show every fitting and appurtenance for each utility. Each contractor is expected to have included in his/her bid sufficient fittings, material, and labor to allow for adjustments in routing of utilities made necessary by the coordination process and to provide a complete and functional system.

5. The contractors will not be allowed additional costs or time extensions due to participation in the coordination process.

6. The contractors will not be allowed additional costs or time extensions for additional fittings, reroutings or changes of duct size, that are essentially equivalent sizes to those shown on the drawings and determined necessary through the coordination process.

7. The A/E reserves the right to determine space priority of equipment in the event of spatial conflicts or interference between equipment, piping, conduit, ducts, and equipment provided by the trades.

8. Changes to the contract documents that are necessary for systems installation and coordination shall be brought to the attention of the A/E.

9. Access panels shall preferably occur only in gypsum board walls or plaster ceilings where indicated on the drawings.

   a. Access to mechanical, electrical, technology, and other items located above the ceiling shall be through accessible lay-in ceiling tile areas.

   b. Potential layout changes shall be made to avoid additional access panels.

   c. Additional access panels shall not be allowed without written approval from the A/E at the coordination drawing stage.

   d. Providing additional access panels shall be considered after other alternatives are reviewed and discarded by the A/E and the Owner's Representative.

   e. When additional access panels are required, they shall be provided without additional cost to the Owner.

10. Complete the coordination drawing process and obtain sign off of the drawings by all contractors prior to installing any of the components.

11. Conflicts that result after the coordination drawings are signed off shall be the responsibility of the contractor or subcontractor who did not properly identify their work requirements, or installed their work without proper coordination.

12. Updated coordination drawings that reflect as-built conditions may be used as record documents.

1.5 QUALITY ASSURANCE

A. Contractor's Responsibility Prior to Submitting Pricing Data:

1. The Contractor is responsible for constructing complete and operating systems. The Contractor acknowledges and understands that the Contract Documents are a two-dimensional representation of a three-dimensional object, subject to human interpretation. This representation may include imperfect data, interpreted codes, utility guidelines, three-dimensional conflicts, and required field coordination items. Such deficiencies can be corrected when identified prior to ordering material and starting installation. The Contractor agrees to carefully study and compare the individual Contract Documents and report at once in writing to the Design Team any deficiencies the Contractor may discover. The Contractor further agrees to require each subcontractor to likewise study the documents and report at once any deficiencies discovered.

2. The Contractor shall resolve all reported deficiencies with the Architect/Engineer prior to awarding any subcontracts, ordering material, or starting any work with the Contractor's own employees. Any work performed prior to receipt of instructions from the Design Team will be done at the Contractor's risk.

B. Qualifications:

1. Only products of reputable manufacturers are acceptable.

2. All Contractors and subcontractors shall employ only workers skilled in their trades.

C. Compliance with Codes, Laws, Ordinances:

1. Conform to all requirements of the City of Madison, Wisconsin Codes, Laws, Ordinances and other regulations having jurisdiction.

2. Conform to all State Codes.

3. If there is a discrepancy between the codes and regulations and these specifications, the Architect/Engineer shall determine the method or equipment used.

4. If the Contractor notes, at the time of bidding, any parts of the drawings or specifications that do not comply with the codes or regulations, he shall inform the Architect/Engineer in writing, requesting a clarification. If there is insufficient time for this procedure, he shall submit with his proposal a separate price to make the system comply with the codes and regulations.

5. All changes to the system made after letting of the contract, to comply with codes or requirements of Inspectors, shall be made by the Contractor without cost to the Owner.

6. If there is a discrepancy between manufacturer's recommendations and these specifications, the manufacturer's recommendations shall govern.

7. All rotating shafts and/or equipment shall be completely guarded from all contact. Partial guards and/or guards that do not meet all applicable OSHA standards are not acceptable. Contractor is responsible for providing this guarding if it is not provided with the equipment supplied.

D. Permits, Fees, Taxes, Inspections:

1. Procure all applicable permits and licenses.

2. Abide by all laws, regulations, ordinances, and other rules of the State or Political Subdivision where the work is done, or as required by any duly constituted public authority.

3. Pay all charges for permits or licenses.

4. Pay all fees and taxes imposed by the State, Municipal and/or other regulatory bodies.

5. Pay all charges arising out of required inspections by an authorized body.

6. Pay all charges arising out of required contract document reviews associated with the project and as initiated by the Owner or authorized agency/consultant.

7. Where applicable, all fixtures, equipment and materials shall be approved or listed by Underwriter's Laboratories, Inc.

E. Examination of Drawings:

1. The drawings for the fire protection work are completely diagrammatic, intended to convey the scope of the work and to indicate the general arrangements and locations of equipment, outlets, etc., and the approximate sizes of equipment.

2. Contractor shall determine the exact locations of equipment and rough-ins, and the exact routing of pipes and ducts to best fit the layout of the job.

3. Scaling of the drawings is not sufficient or accurate for determining these locations.

4. Where job conditions require reasonable changes in indicated arrangements and locations, such changes shall be made by the Contractor at no additional cost to the Owner.

5. Because of the scale of the drawings, certain basic items, such as fittings, boxes, valves, unions, etc., may not be shown, but where required by other sections of the specifications or required for proper installation of the work, such items shall be furnished and installed.

6. If an item is either on the drawings or in the specifications, it shall be included in this contract.

7. Determination of quantities of material and equipment required shall be made by the Contractor from the documents. Where discrepancies arise between drawings, schedules and/or specifications, the greater number shall govern.

8. Where used in fire protection documents, the word "furnish" shall mean supply for use, the word "install" shall mean connect complete and ready for operation, and the word "provide" shall mean to supply for use and connect complete and ready for operation.

   a. Any item listed as furnished shall also be installed, unless otherwise noted.

   b. Any item listed as installed shall also be furnished, unless otherwise noted.

F. Field Measurements:

1. Verify all pertinent dimensions at the job site before ordering any materials or fabricating any supports, pipes or ducts.

G. Electronic Media/Files:

1. Construction drawings for this project have been prepared utilizing Revit.

2. Contractors and Subcontractors may request electronic media files of the contract drawings and/or copies of the specifications. Specifications will be provided in PDF format.

3. Upon request for electronic media, the Contractor shall complete and return a signed "Electronic File Transmittal" form provided by KJWW.

4. If the information requested includes floor plans prepared by others, the Contractor will be responsible for obtaining approval from the appropriate Design Professional for use of that part of the document.

5. The electronic contract documents can be used for preparation of shop drawings and as-built drawings only. The information may not be used in whole or in part for any other project.

6. The drawings prepared by KJWW for bidding purposes may not be used directly for ductwork layout drawings or coordination drawings.

7. The use of these electronic files by the Contractor does not relieve them from their responsibility for coordination of work with other trades and verification of space available for the installation.

8. The information is provided to expedite the project and assist the Contractor with no guarantee by KJWW as to the accuracy or correctness of the information provided. KJWW accepts no responsibility or liability for the Contractor's use of these documents.

1.6 SUBMITTALS

A. Submittals shall be required for the following items, and for additional items where required elsewhere in the specifications or on the drawings.

1. Submittals list:

Referenced Specification Section	Submittal Item
21 05 00	Owner Training Agenda
21 13 00	Sprinkler Systems
21 13 00	Fire Protection Equipment

B. General Submittal Procedures: In addition to the provisions of Division 1, the following are required:

1. Transmittal: Each transmittal shall include the following:

   a. Date
   b. Project title and number
   c. Contractor's name and address
   d. Division of work (e.g., plumbing, heating, ventilating, etc.)
   e. Description of items submitted and relevant specification number
   f. Notations of deviations from the contract documents
   g. Other pertinent data

2. Submittal Cover Sheet: Each submittal shall include a cover sheet containing:

   a. Date
   b. Project title and number
   c. Architect/Engineer
   d. Contractor and subcontractors' names and addresses
   e. Supplier and manufacturer's names and addresses
   f. Division of work (e.g., plumbing, heating, ventilating, etc.)
   g. Description of item submitted (using project nomenclature) and relevant specification number
   h. Notations of deviations from the contract documents
   i. Other pertinent data
   j. Provide space for Contractor's review stamps

3. Composition:

   a. Submittals shall be submitted using specification sections and the project nomenclature for each item.

   b. Individual submittal packages shall be prepared for items in each specification section. All items within a single specification section shall be packaged together where possible. An individual submittal may contain items from multiple specifications sections if the items are intimately linked (e.g., pumps and motors).

   c. All sets shall contain an index of the items enclosed with a general topic description on the cover.

4. Content: Submittals shall include all fabrication, erection, layout, and setting drawings; manufacturers' standard drawings; schedules; descriptive literature, catalogs and brochures; performance and test data; wiring and control diagrams; dimensions; shipping and operating weights; shipping splits; service clearances; and all other drawings and descriptive data of materials of construction as may be required to show that the materials, equipment or systems and the location thereof conform to the requirements of the contract documents.

5. Contractor's Approval Stamp:

   a. The Contractor shall thoroughly review and approve all shop drawings before submitting them to the Architect/Engineer. The Contractor shall stamp, date and sign each submittal certifying it has been reviewed.

   b. Unstamped submittals will be rejected.

   c. The Contractor's review shall include, but not be limited to, verification of the following:

      1.) Only approved manufacturers are used.
      2.) Addenda items have been incorporated.
      3.) Catalog numbers and options match those specified.
      4.) Performance data matches that specified.
      5.) Electrical characteristics and loads match those specified.
      6.) Equipment connection locations, sizes, capacities, etc. have been coordinated with other affected trades.
      7.) Dimensions and service clearances are suitable for the intended location.
      8.) Equipment dimensions are coordinated with support steel, housekeeping pads, openings, etc.
      9.) Constructability issues are resolved (e.g., weights and dimensions are suitable for getting the item into the building and into place, sinks fit into countertops, etc.).

   d. The Contractor shall review, stamp and approve all subcontractors' submittals as described above.

   e. **The Contractor's approval stamp is required on all submittals. Approval will indicate the Contractor's review of all material and a complete understanding of exactly what is to be furnished. Contractor shall clearly mark all deviations from the contract documents on all submittals. If deviations are not marked by the Contractor, then the item shall be required to meet all drawing and specification requirements.**

6. Submittal Identification and Markings:

   a. The Contractor shall clearly mark each item with the same nomenclature applied on the drawings or in the specifications.

b. The Contractor shall clearly indicate the size, finish, material, etc.

c. Where more than one model is shown on a manufacturer's sheet, the Contractor shall clearly indicate exactly which item and which data is intended.

d. All marks and identifications on the submittals shall be unambiguous.

7. Schedule submittals to expedite the project. Coordinate submission of related items.

8. Identify variations from the contract documents and product or system limitations that may be detrimental to the successful performance of the completed work.

9. Reproduction of contract documents alone is not acceptable for submittals.

10. Incomplete submittals will be rejected without review. Partial submittals will only be reviewed with prior approval from the Architect/Engineer.

11. Submittals not required by the contract documents may be returned without review.

12. The Architect/Engineer's responsibility shall be to review one set of shop drawing submittals for each product. If the first submittal is incomplete or does not comply with the drawings and/or specifications, the Contractor shall be responsible to bear the cost for the Architect/Engineer to recheck and handle the additional shop drawing submittals.

13. Submittals shall be reviewed and approved by the Architect/Engineer **before** releasing any equipment for manufacture or shipment.

14. Contractor's responsibility for errors, omissions or deviation from the contract documents in submittals is not relieved by the Architect/Engineer's approval.

C. Electronic Submittal Procedures:

1. Distribution: Email submittals as attachments to all parties designated by the Architect/Engineer, unless a web-based submittal program is used.

2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.

3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.

4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

a. Submittal file name: 21 XX XX.description.YYYYMMDD
b. Transmittal file name: 21 XX XX.description.YYYYMMDD

5. File Size: Electronic file size shall be limited to a maximum of 4MB. Larger files shall be transmitted via a pre-approved method.

1.7 PRODUCT DELIVERY, STORAGE, HANDLING & MAINTENANCE

A. Exercise care in transporting and handling to avoid damage to materials. Store materials on the site to prevent damage. Keep materials clean, dry and free from harmful conditions. Immediately remove any materials that become wet or that are suspected of becoming contaminated with mold or other organisms.

B. Keep all bearings properly lubricated and all belts properly tensioned and aligned.

C. Coordinate the installation of heavy and large equipment with the General Contractor and/or Owner. If the Mechanical Contractor does not have prior documented experience in rigging and lifting similar equipment, he/she shall contract with a qualified lifting and rigging service that has similar documented experience. Follow all equipment lifting and support guidelines for handling and moving.

D. Contractor is responsible for moving equipment into the building and/or site. Contractor shall review site prior to bid for path locations and any required building modifications to allow movement of equipment. Contractor shall coordinate his/her work with other trades.

1.8 WARRANTY

A. Refer to Division 01 specification for requirements.

1.9 INSURANCE

A. Contractor shall maintain insurance coverage as set forth in Division 0 of these specifications.

1.10 MATERIAL SUBSTITUTION

A. Refer to Division 01 specification for requirements.

1.11 LEED REQUIREMENTS

A. This project is pursuing a LEED Silver certification in accordance with USGBC LEED Rating System for New Construction Version 2009. The Contractor shall provide all services and documentation necessary to achieve this rating.

B. Refer to Division 01 specification for additional requirements.

1.12 PROJECT COMMISSIONING

A. The Contractor shall work with the Commissioning Agent (CxA) as described in Division 01 specifications, and provide all services necessary for compliance with LEED Prerequisite EAp1, Fundamental Commissioning, and EAc3 Enhanced Commissioning.

PART 2 - PRODUCTS

NOT APPLICABLE

PART 3 - EXECUTION

3.1 JOBSITE SAFETY

A. Neither the professional activities of the Architect/Engineer, nor the presence of the Architect/Engineer or his or her employee and subconsultants at a construction site, shall relieve the Contractor and other entity of their obligations, duties and responsibilities including, but not limited to, construction means, methods, sequence, techniques or procedures necessary for performing, superintending or coordinating all portions of the work of construction in accordance with the contract documents and any health or safety precautions required by any regulatory agencies. The Architect/Engineer and his or her personnel have no authority to exercise any control over any construction contractor or other entity or their employees in connection with their work or any health or safety precautions. The Contractor is solely responsible for jobsite safety. The Architect/Engineer and the Architect/Engineer's consultants shall be indemnified and shall be made additional insureds under the Contractor's general liability insurance policy.

3.2 OPERATION AND MAINTENANCE MANUALS

A. Refer to Division 01 specification for requirements.

3.3 INSTRUCTING THE OWNER'S REPRESENTATIVES

A. Adequately instruct the Owner's designated representatives in the maintenance, care, and operation of all systems installed under this contract per specification 01 79 00.

B. The instructions shall include:

1. Explanation of all system flow diagrams.
2. Maintenance of equipment.
3. Start-up procedures for all major equipment.
4. Description of emergency system operation.

C. Minimum hours of instruction for each item shall be:

1. Sprinkler System(s) - 1 hour.

3.4 SYSTEM COMMISSIONING

A. The fire protection systems shall be complete and operating. System start-up, testing, balancing, and satisfactory system performance is the responsibility of the Contractor. This includes calibration and adjustments of all controls, noise level adjustments and final comfort adjustments as required.

B. All operating conditions and control sequences shall be tested during the start-up period. Test all interlocks, safety shutdowns, controls, and alarms.

C. The Contractor, subcontractors, and equipment suppliers shall have skilled technicians to ensure that all systems perform properly. If the Architect/Engineer is requested to visit the job site for trouble shooting, assisting in start-up, obtaining satisfactory equipment operation, resolving installation and/or workmanship problems, equipment substitution issues or unsatisfactory system performance, including call backs during the warranty period, through no fault of the design; the Contractor shall reimburse the Owner on a time and materials basis for services rendered at the Architect/Engineer's standard hourly rates in effect when the services are requested. The Contractor shall pay the Owner for services required that are product, installation or workmanship related. Payment is due within 30 days after services are rendered.

3.5 RECORD DOCUMENTS

A. The following paragraph supplements Division 1 requirements:

Contractor shall maintain at the job site a separate and complete set of fire protection drawings and specifications on which he shall clearly and permanently mark in complete detail all changes made to the fire protection systems.

B. Mark drawings to indicate revisions to piping size and location, both exterior and interior; including locations of other control devices, and other units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned from column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located; Change Orders; concealed control system devices.

C. Mark specifications to show approved substitutions; Change Orders, and actual equipment and materials used.

D. Record changes daily and keep the marked drawings available for the Architect/Engineer's examination at any normal work time.

E. Upon completing the job, and before final payment is made, give the marked-up drawings to the Architect/Engineer.

3.6 ADJUST AND CLEAN

A. Thoroughly clean all equipment and systems prior to the Owner's final acceptance of the project. Clean all foreign paint, grease, oil, dirt, labels, stickers, and other foreign material from all equipment.

B. Clean all areas where moisture is present. Immediately report any mold, biological growth, or water damage.

C. Remove all rubbish, debris, etc., accumulated during construction from the premises.

3.7 CONSTRUCTION WASTE MANAGEMENT

A. This Contractor shall comply with all construction and demolition waste disposal and recycling requirements outlined in LEED MRc2: Construction Waste Management (follow latest edition at the time of bidding or as referenced in these specifications).

1. This Contractor shall coordinate with the General Contractor to develop and implement a construction waste management plan that, at a minimum, identifies the materials to be diverted from disposal and whether the materials will be sorted on-site or co-mingled.

2. The Contractor shall track waste disposal and recycling efforts throughout the construction process for all materials associated with this Contractor's scope of work. The Contractor shall provide this information to the General Contractor so that it can be incorporated with similar information from all other contractors for the project.

    a. Calculations for waste and recycled material can be done by weight or volume, but they must be consistent throughout the project. The Contractor shall coordinate with the General Contractor to establish the preferred calculation method and report the results accordingly.

    b. Excavated soil and land-clearing debris do not count towards the waste disposal or recycled material.

3. At a minimum, 50% of the construction and demolition debris for this project must be recycled or salvaged.

END OF SECTION

READINESS CERTIFICATION PRIOR TO FINAL JOBSITE OBSERVATION

In order to prevent the final job observation from occurring too early, we require that the Contractor review the completion status of the project and, by copy of this document, certify that the job is indeed ready for the final job observation. The following is a typical list of items that represent the degree of job completeness expected prior to your requesting a final job observation.

1. Penetrations fire sealed and labeled in accordance with specifications.
2. Fire protection system operational.
3. Pipes labeled.

Accepted by:

Prime Contractor _____

By _____ Date _____

Upon Contractor certification that the project is complete and ready for a final job observation, we require the Contractor to sign this agreement and return it to the Architect/Engineer so that the final observation can be scheduled.

It is understood that if the Architect/Engineer finds the job not ready for the final observation and that additional trips and observations are required to bring the project to completion, the costs incurred by the Architect/Engineers for additional time and expenses will be deducted from the Contractor's contract retainage prior to final payment at the completion of the job.

* * * * *

SECTION 21 05 29
FIRE SUPPRESSION SUPPORTS AND ANCHORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Hangers, Supports, and Associated Anchors.
B. Equipment Bases and Supports.
C. Sleeves and Seals.
D. Flashing and Sealing of Equipment and Pipe Stacks.
E. Cutting of Openings.
F. Escutcheon Plates and Trim.

1.2 QUALITY ASSURANCE

A. Support Sprinkler Piping in conformance with NFPA 13.

B. Support Standpipes in conformance with NFPA 14.

1.3 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 21 05 00.

1.4 WORK FURNISHED BUT INSTALLED UNDER OTHER SECTIONS

A. Furnish sleeves and hanger inserts to General Contractor for placement into formwork.

PART 2 - PRODUCTS

2.1 SEISMIC RESTRAINTS

A. Refer to Section 21 05 50 for additional requirements for seismic restraints.

2.2 HANGER RODS

A. Hanger rods for single rod hangers shall conform to the following:

Pipe Size	Hanger Rod Diameter	
	Column #1	Column #2
2" and smaller	3/8"	3/8"
2-1/2" through 3-1/2"	1/2"	1/2"
4" and 5"	5/8"	1/2"
6"	3/4"	5/8"
8" through 12"	7/8"	3/4"
14"	1"	7/8"
16" and 18"	1"	N/A
20" and 24"	1-1/4"	N/A

Column #1: Steel pipe.
Column #2: Copper and plastic pipe.

B. Rods for double rod hangers may be reduced one size. Minimum rod diameter is 3/8 inches.

C. Hanger rods and accessories used in mechanical spaces or otherwise dry areas shall have ASTM B633 electro-plated zinc finish.

2.3 PIPE HANGERS AND SUPPORTS

A. All pipe hangers, clamps, and supports shall conform to Manufacturers Standardization Society MSS-SP-58 and 127 (where applicable).

B. Support and laterally brace vertical pipes at every floor level in multi-story structures, and more frequently when required by applicable codes, but never at intervals over 15 feet. Support vertical pipes with riser clamps installed below hubs, couplings or lugs. Provide sufficient flexibility to accommodate expansion and contraction without compromising fire barrier penetrations and other fixed takeoff locations.

Acceptable Products:

Anvil -	Fig. CT121
Cooper/B-Line -	Fig. B3373CT
Erico -	Model 510
Nibco/Tolco -	Fig. 82

C. Hangers in direct contact with copper pipe shall be coated with plastic with appropriate temperature range. HYDRA-ZORB clamps are permitted for this application for bare pipes within their temperature limits of -65°F to +275°F.

D. Unless otherwise indicated, hangers shall be as follows:

1. Clevis Type:
Service: Bare Metal Pipe

Acceptable Products:	Bare Steel, Plastic or Insulated Pipe	Bare Copper Pipe
Anvil	Fig. 260	Fig. CT65
Cooper/B-Line	Fig. 3100	Fig. B3104CT
Erico	Model 400	Model 402
Nibco/Tolco	Fig. 1	Fig. 81

2. Adjustable Swivel Ring Type:
Service: Bare Metal Pipe - 4 inches and Smaller

Acceptable Products:	Bare Steel Pipe	Bare Copper Pipe
Anvil	Fig. 69	Fig. CT69
Cooper/B-Line	Fig. B3170NF	Fig. B170CT
Erico	Model FCN	
Nibco/Tolco	Fig. 200	Fig. 202

E. Support may be fabricated from U-Channel strut or similar shapes. Piping less than 4" in diameter shall be secured to strut with clamps of proper design and capacity as required to maintain spacing and alignment. Strut shall be independently supported from hanger drops or building structure. Size and support shall be per manufacturer's installation requirements for structural support of piping. Clamps shall not interrupt piping insulation.

1. Strut used in mechanical spaces or otherwise dry areas shall have ASTM B633 electro-plated zinc finish.

2. Strut used in damp areas listed in hanger rods shall have ASTM A123 hot-dip galvanized finish applied after fabrication.

F. Unless otherwise indicated, pipe supports for use with struts shall be as follows:

1. Clamp Type:
Service: Bare Metal Pipe

a. Clamps in direct contact with copper pipe shall be plastic coated.

b. Pipes subject to expansion and contraction shall have clamps slightly oversized to allow limited pipe movement.

Acceptable Products:	Bare Steel, Plastic or Insulated Pipe	Bare Copper Pipe
Unistrut	Fig. P1100 or P2500	
Cooper/B-Line	Fig. B2000 or B2400	Fig. BVT
Nibco/Tolco	Fig. A-14 or 2STR	

G. Unless otherwise shown, upper attachments for hanger rods or support struts shall be as follows:

1. Beam Clamps:

Acceptable Products:	
Anvil	Fig. 228, 292
Cooper/B-Line	Fig. B3054
Erico	Model 360
Nibco/Tolco	Fig. 329

2. Concrete Inserts, Single Rod Galvanized:

Acceptable Products:	
Anvil	Fig. 282
Cooper/B-Line	Fig. B3014
Erico	Model 355
Nibco/Tolco	Fig. 310

3. Concrete Inserts, Continuous Strip Galvanized:

Acceptable Products:	
Unistrut Corp	P3200 Series
Cooper/B-Line	Fig. B22-J
Erico	CONCT

4. Concrete Anchors: Fasten to concrete using cast-in or post-installed anchors designed per the requirements of Appendix D of ACI 318-14. Post-installed anchors shall be qualified for use in cracked concrete by ACI-355.2.

5. Masonry Anchors: Fasten to concrete masonry units with expansion anchors or self-tapping masonry screws. For expansion anchors into hollow concrete block, use sleeve-type anchors designed for the specific application. Do not fasten in masonry joints. Do not use powder actuated fasteners, wooden plugs, or plastic inserts.

H. Wall supports shall be used where vertical height of structure exceeds minimum spacing requirements. Install wall supports at same spacing as hangers or strut supports along vertical length of pipe runs.

I. Welding:

1. Unless otherwise noted, hangers, clips, and auxiliary support steel may be welded in lieu of bolting, clamping, or riveting to the building structural frame. Take adequate precautions during all welding operations for fire prevention and for protecting walls and ceilings from being damaged by smoke.

2.4 FOUNDATIONS, BASES, AND SUPPORTS

A. Basic Requirements:

1. Furnish and install foundations, bases, and supports (not specifically indicated on the Drawings or in the Specifications of either the General Construction or Mechanical work as provided by another Contractor) for mechanical equipment.

2. All concrete foundations, bases and supports, shall be reinforced. All steel bases and supports shall receive a prime coat of zinc chromate or red metal primer. After completion of work, give steel supports a final coat of gray enamel.

B. Supports:

1. Provide sufficient clips, inserts, hangers, racks, rods, and auxiliary steel to securely support all suspended material, equipment and conduit without sag.

2. Hang heavy equipment from concrete floors or ceilings with Architect-approved concrete inserts, furnished and installed by the Contractor whose work requires them, except where indicated otherwise.

C. Grout:

1. Grout shall be non-shrinking premixed (Master Builders Company "Embecco"), unless otherwise indicated on the drawings or approved by the Architect/Engineer.

2. Use Mix No. 1 for clearances of 1" or less, and Mix No. 2 for all larger clearances.

3. Grout under equipment bases, around pipes, at pipe sleeves, etc., and where shown on the drawings.

2.5 OPENINGS IN FLOORS, WALLS AND CEILINGS

A. Exact locations of all openings for the installation of materials shall be determined by the Contractor and given to the General Contractor for installation or construction as the structure is built.

B. Coordinate all openings with other Contractors.

C. Hire the proper tradesman and furnish all labor, material and equipment to cut openings in or through existing structures, or openings in new structures that were not installed, or additional openings. Repair all spalling and damage to the satisfaction of the Architect/Engineer. Make saw cuts before breaking out concrete to ensure even and uniform opening edges.

D. Said cutting shall be at the complete expense of each Contractor. Failure to coordinate openings with other Contractors shall not exempt the Contractor from providing openings at his expense.

E. Do not cut structural members without written approval of the Architect or Structural Engineer.

2.6 PIPE SLEEVES AND LINTELS

A. Each Contractor shall provide pipe sleeves and lintels for all openings required for the Contractor’s work in masonry walls and floors, unless specifically shown as being by others.

B. Fabricate all sleeves from standard weight black steel pipe or as indicated on the drawings. Provide continuous sleeve. Cut or split sleeves are not acceptable.

C. Fabricate all lintels for masonry walls from structural steel shapes or as indicated on the drawings. Have all lintels approved by the Architect or Structural Engineer.

D. Sleeves through the floors on exposed risers shall be flush with the ceiling, with planed squared ends extending 1" above the floor in unfinished areas, and flush with the floor in finished areas, to accept spring closing floor plates.

E. Sleeves shall not penetrate structural members or masonry walls without approval from the Structural Engineer. Sleeves shall then comply with the Engineer's design.

F. Openings through unexcavated floors and/or foundation walls below the floor shall have a smooth finish with sufficient annular space around material passing through opening so slight settling will not place stress on the material or building structure.

G. Install all sleeves concentric with pipes. Secure sleeves in concrete to wood forms. This Contractor is responsible for sleeves dislodged or moved when pouring concrete.

H. Where pipes rise through concrete floors that are on earthen grade, provide 3/4" resilient expansion joint material (asphalt and cork) wrapped around the pipe, the full depth of concrete, at the point of penetration. Secure to prevent shifting during concrete placement and finishing.

I. Size sleeves large enough to allow expansion and contraction movement. Provide continuous insulation wrapping.

2.7 ESCUTCHEON PLATES AND TRIM

A. Fit escutcheons to all insulated or uninsulated exposed pipes passing through walls, floors, or ceilings of finished rooms.

B. Escutcheons shall be heavy gauge, cold rolled steel, copper coated under a chromium plated finish, heavy spring clip, rigid hinge and latch.

C. Install galvanized steel (unless otherwise indicated) trim strip to cover vacant space and raw construction edges of all rectangular openings in finished rooms. This includes duct and pipe openings.

2.8 PIPE PENETRATIONS

A. Seal all pipe penetrations. Seal non-rated walls and floor penetrations with grout or caulk. Backing material may be used.

B. Seal fire rated wall and floor penetrations with fire seal system as specified.

2.9 PIPE ANCHORS

A. Provide all items needed to allow adequate expansion and contraction of all piping. All piping shall be supported, guided, aligned, and anchored as required.

B. Repair all piping leaks and associated damage. Pipes shall not rub on any part of the building.

2.10 FINISH

A. Prime coat exposed steel hangers and supports. Hangers and supports in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

PART 3 - EXECUTION

3.1 FIRE SUPPRESSION SUPPORTS AND ANCHORS

A. General Installation Requirements:

1. Install all items per manufacturer's instructions.

2. Coordinate the location and method of support of piping systems with all installations under other Divisions and Sections of the Specifications.

3. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

B. Supports Requirements:

1. Install roof pipe supports to resist wind movement per manufacturer's recommendations. Method of securing base to roof shall be compatible with roofing materials.

2. Where building structural steel is fireproofed, all hangers, clamps, auxiliary steel, etc., which attach to it shall be installed prior to application of fireproofing. Repair all fireproofing damaged during pipe installation.

3. Set all concrete inserts in place before pouring concrete.

4. Furnish, install and prime all auxiliary structural steel for support of piping systems that are not shown on the Drawings as being by others.

5. Install hangers and supports complete with lock nuts, clamps, rods, bolts, couplings, swivels, inserts and required accessories.

6. Hangers for horizontal piping shall have adequate means of vertical adjustment for alignment.

C. Pipe Requirements:

1. Support all piping and equipment, including valves, strainers, and other specialties and accessories to avoid objectionable or excessive stress, deflection, swaying, sagging or vibration in the piping or building structure during erection, cleaning, testing and normal operation of the systems.

2. Do not, however, restrain piping to cause it to snake or buckle between supports or to prevent proper movement due to expansion and contraction.

3. Support piping at equipment and valves so they can be disconnected and removed without further supporting the piping.

4. Piping shall not introduce strains or distortion to connected equipment.

5. Parallel horizontal pipes may be supported on trapeze hangers made of structural shapes and hanger rods; otherwise, pipes shall be supported with individual hangers.

6. Trapeze hangers may be used where ducts interfere with normal pipe hanging.

7. Provide additional supports where pipe changes direction, adjacent to flanged valves and strainers, at equipment connections and heavy fittings.

8. Provide at least one hanger adjacent to each joint in grooved end steel pipe with mechanical couplings.

D. Provided the installation complies with all loading requirements of truss and joist manufacturers, the following practices are acceptable:

1. Loads of 100 lbs. or less may be attached anywhere along the top or bottom chords of trusses or joists with a minimum 3'spacing between loads.

2. Loads greater than 100 lbs. must be hung concentrically and may be hung from top or bottom chord, provided one of the following conditions is met:

a. The hanger is attached within 6” from a web/chord joint.

b. Additional L2x2x1/4 web reinforcement is installed per manufacturer’s requirements.

3. It is prohibited to cantilever a load using an angle or other structural component that is attached to a truss or joist in such a fashion that a torsional force is applied to that structural member.

4. If conditions cannot be met, coordinate installation with truss or joist manufacturer and contact Architect/Engineer.

E. After piping and insulation installation are complete, cut hanger rods back at trapeze supports so they do not extend more than 3/4" below bottom face of lowest fastener and blunt any sharp edges.

F. Do not exceed 25 lbs. per hanger and a minimum spacing of 2’-0” on center when attaching to metal roof decking (limitation not required with concrete on metal deck). This 25 lbs. load and 2’-0” spacing include adjacent electrical and architectural items hanging from deck. If the hanger restrictions cannot be achieved, supplemental framing off steel framing will need to be added.

G. Do not exceed the manufacturer's recommended maximum load for any hanger or support.

H. Spacing of Hangers shall not exceed the compressive strength of the insulation inserts, and in no case shall exceed the following:

	Pipe Material	Maximum Spacing
1.	Steel (Std. Weight or Heavier – Liquid Service):	
	1-1/4" & under	7'-0"
	1-1/2"	9'-0"
	2"	10'-0"
	2-1/2"	11'-0"
	3"	12'-0"
	4" & larger	12'-0"
2.	Hard Drawn Copper & Brass (Liquid Service):	
	3/4" and under	5'-0"
	1"	6'-0"
	1-1/4"	7'-0"
	1-1/2"	8'-0"
	2"	8'-0"
	2-1/2"	9'-0"
	3"	10'-0"
	4"	12'-0"
	6"	12'-0"

3. Rigid Plastic Pipe:

a. Space hangers at 4’-0” maximum centers.

4. Installation of hangers shall conform to MSS SP-58 and applicable NFPA standards.

END OF SECTION

SECTION 21 05 53
FIRE SUPPRESSION IDENTIFICATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Identification of products installed under Division 21.

1.2 REFERENCES

A. ANSI/ASME A13.1 - Scheme for the Identification of Piping Systems.

B. ASTM B-1, B-3, and B-8 for copper conductors.

C. ASTM D-1248 for Polyethylene Extrusion Materials, ICEA S-70-547 Weatherproof Resistant Polyethylene Conductors, ICEA S-61-402/NEMA WC5 Thermoplastic Insulated Wire & Cable, ICEA S-95-658/NEMA WC70 Non-Shielded 0 – 2kv Cables.

D. UL 1581 Standard for Electrical Wires, Cables, and Flexible Cords.

1.3 SUBMITTALS

A. Submit shop drawings under provisions of Section 21 05 00. Include list of items identified, wording, letter sizes, and color coding.

B. Include valve chart and schedule listing valve tag number, location, function, and valve manufacturer's name and model number.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. 3M, Bunting, Calpico, Craftmark, Emedco, Kolbi Industries, Seton, W.H. Brady, Marking Services.

2.2 MATERIALS

A. All pipe markers (purchased or stenciled) shall conform to ANSI A13.1. Marker lengths and letter sizes shall be at least the following:

O.D. of Pipe or insulation	Marker Length	Size of Letters
Up to and including 1-1/4”	8”	1/2”
1-1/2” to 2”	8”	3/4”
2-1/2” to 6”	12”	1-1/4
8” to 10”	24”	2-1/2”
Over 10”	32”	3-1/2”

Plastic tags may be used for outside diameters under 3/4".

B. Plastic Nameplates: Laminated three-layer phenolic with engraved black, 1/4" minimum letters on light contrasting background.

C. Aluminum Nameplates: Black enamel background with natural aluminum border and engraved letters furnished with two mounting holes and screws.

D. Plastic Tags: Minimum 1-1/2" square or round laminated three-layer phenolic with engraved, 1/4” minimum black letters on light contrasting background.

E. Brass Tags: Brass background with engraved black letters. Tag size minimum 1-1/2" square or 1-1/2" round.

F. Plastic Pipe Markers: Semi-rigid plastic, preformed to fit around pipe or pipe covering; indicating flow direction and fluid conveyed.

G. Vinyl Pipe Markers: Colored vinyl with permanent pressure sensitive adhesive backing.

H. Stencil Painted Pipe Markers: Use industrial enamel spray paint per ANSI Standard A13.1. Indicate fluid conveyed and flow direction.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all products per manufacturer’s recommendations.

B. Degrease and clean surfaces to receive adhesive for identification materials.

C. Valves:

1. All valves (except shutoff valves at equipment) shall have numbered tags.

2. Provide or replace numbered tags on all existing valves that are connected to new systems or that have been revised.

3. Provide all existing valves used to extend utilities to this project with numbered tags. Review tag numbering sequence with the Owner prior to ordering tags.

4. Secure tags with heavy duty key chain and brass "S" link or with mechanically fastened plastic straps.

5. Attach to handwheel or around valve stem. On lever operated valves, drill the lever to attach tags.

6. Number all tags and show the service of the pipe.

7. Provide two sets of laminated 8-1/2" x 11" copies of a valve directory listing all valves, with respective tag numbers, uses, and locations. The directory shall be reviewed by the Owner and Architect/Engineer prior to laminating final copies. Laminated copies shall have brass eyelet in at least one corner for easy hanging.

D. Pipe Markers:

1. Adhesive Backed Markers: Use Brady Style 1, 2, or 3 on pipes 3" diameter and larger. Use Brady Style 4, 6, or 8 on pipes under 3" diameter. Similar styles by other listed manufacturers are acceptable. Secure all markers at both ends with a wrap of pressure sensitive tape completely around the pipe.

2. Snap-on Markers: Use Seton "Setmark" on pipes up to 5-7/8" OD. Use Seton "Setmark" with nylon or Velcro ties for pipes 6" OD and over. Similar styles by other listed manufacturers are acceptable.

3. Stencil Painted Pipe Markers:

   a. Remove rust, grease, dirt, and all foreign substances from the pipe surface.
   b. Apply primer on non-insulated pipes before painting.
   c. Use background and letter colors as scheduled later in this section.

4. Apply markers and arrows in the following locations where clearly visible:

   a. At each valve.
   b. On both sides of walls that pipes penetrate.
   c. At least every 20 feet along all pipes.
   d. On each riser and each leg of each "T" joint.
   e. At least once in every room and each story traversed.

E. Equipment:

1. All equipment not easily identifiable such as controls, relays, gauges, etc.; and all equipment in an area remote from its function shall have nameplates or plastic tags listing name, function, and drawing symbol. Do not label exposed equipment in public areas.

2. Fasten nameplates or plastic tags with stainless steel self-tapping screws or permanently bonding cement.

3. Mechanical equipment that is not covered by the U.S. National Appliance Energy Conservation Act (NAECA) of 1987 shall carry a permanent label installed by the manufacturer stating that the equipment complies with the requirements of ASHRAE 90.1.

3.2 SCHEDULE

A. Pipes to be marked shall be labeled with the text as shown in the following table regardless of which method or material is used:

Pipe Service	Lettering Color	Background Color
FIRE PROTECTION WATER	White	Red

END OF SECTION

SECTION 21 13 00
FIRE PROTECTION SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Pipe, Fittings, Valves, and Connections for Fire Protection System.
B. Wet-Pipe Sprinkler System.

1.2 QUALITY ASSURANCE

A. Welding Materials and Procedures: Conform to ASME Code.

B. Equipment and Components: Bear UL label or marking.

C. Valves: Bear UL label or marking. Provide manufacturer's name and pressure rating marked on valve body. Pressure rating shall match specified pipe system pressure rating. Remanufactured valves are not acceptable.

D. Specialist Firm: Company specializing in sprinkler systems with minimum three years experience.

E. Sprinkler design drawings submitted by the Contractor shall be prepared by a NICET Water-Based Fire Protection Systems Layout Level III or Level IV designer or PE, and signed and sealed by a Professional Engineer licensed in the state where the project is located.

1.3 SUBMITTALS

A. Submit shop drawings per Section 21 05 00. Indicate pipe materials, joining methods, supports, floor and wall penetration seals, sprinklers, equipment data and ratings, and hydraulic calculations.

B. Submit detailed pipe and sprinkler layout and other calculations and forms as described in NFPA 13.

C. Submit detailed working drawings and obtain review of them in the following order:

1. Engineer/Architect.
2. Local Fire Department
3. Owner’s Insurance Company

Begin construction after all approvals are received.

D. Working drawings shall include piping and sprinkler layout, sprinkler types and ratings, sections and elevations at critical points. Show coordination with lighting, ductwork, and diffusers, and indicate basic flow and hydraulic design information, including main location and date that the test was taken.

E. Submit dry-pipe calculations including water delivery time and air supply refill defined in NFPA 13. Water delivery time and air supply shall meet the requirements set forth in NFPA 13.

F. Provide the Owner with one copy of NFPA 25. *Standard for the Inspection Testing and Maintenance of Water-based Fire Protection Systems.*

1.4 EXTRA STOCK

A. Provide metal storage cabinet, wrenches for each sprinkler type, and extra sprinklers per NFPA 13 and applicable building code.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store valves and sprinklers in shipping containers, with labels in place.

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

C. Maintain temporary end caps and closures in place until installation.

1.6 WORK FURNISHED BUT INSTALLED UNDER OTHER SECTIONS

A. Furnish sleeves to General Contractor for placement in walls and floors. Sleeve location to be determined by the Fire Protection Contractor prior to construction. If additional sleeves are required, they shall be core drilled by the Fire Protection Contractor.

1.7 SYSTEM DESCRIPTION

A. System shall cover building areas noted.

B. System shall interface with building fire alarm system. Provide all required wiring.

C. Provide wet pipe sprinkler system to NFPA 13 and building code requirements as required by Owner's insurance company and as shown on the drawings.

D. Provide a Fire Department connection.

1.8 REGULATORY REQUIREMENTS

A. All material, equipment, and installation shall be approved by the Authorities Having Jurisdiction and the Owner's Insurance Company.

B. The Authorities Having Jurisdiction and the Owner's Insurance Company shall have precedence over the drawings and specifications in case of discrepancies.

C. The entire installation shall comply with all applicable codes.

1.9 SYSTEM DESIGN

A. Design and install a complete, hydraulically calculated wet-pipe sprinkler system for the entire building.

B. Provide all required equipment and accessories.

C. System shall include a 5 psi allowance for future decrease in available pressure and an allowance for inside and outside hose streams.

D. Provide monitor switches on all shutoff valves.

E. Install sprinkler riser in location shown on drawings or as approved by the Architect/Engineer.

F. Provide pressure gauge with valve in the main riser.

G. Provide main drain valve piped to outside the building. Locate so discharge does not damage lawn or other surfaces.

H. Provide flow switch in the main riser and as indicated on drawings.

I. Provide horn and strobe and all required wiring.

1.10 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 21 05 00 for required fire protection systems electronic CAD drawings to be provided to Coordinating Contractor for inclusion into composite coordination drawings.

1.11 OPERATION AND MAINTENANCE DATA

A. Submit manufacturers' operation and maintenance data. Include written maintenance data on components of system, servicing requirements, and record drawings.

1.12 JOB CONDITIONS

A. Fire Protection Contractor shall determine the flow and pressure available at the service connection. The Fire Protection Contractor is responsible to verify this information and make all tests required. Base all pipe sizing and hydraulic calculations on flow test data no older than 18 months.

B. Pipe sizing shown on drawings for service entrance and main risers is preliminary for coordination purposes only. Contractor is responsible for final sizing from hydraulic calculations.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

A. Steel Pipe (Inside Building-Above Grade):

1. Pipe: 2" and Under - Schedule 40, black steel, ASTM A53. Threaded and coupled or flanged.
2. Joints: 2" and under - screwed or flanged.
3. Fittings: Screwed - cast iron, 125 lb., black, ANSI/ASME B16.4 or malleable iron, 150 lb., black, ANSI/ASME B16.3. Flanged-cast iron, 125 lb., ANSI/ASME B16.1.

B. Steel Pipe (Inside Building-Above Grade):

1. Pipe: 2-1/2" and Over - Schedule 10, black steel, grooved, ASTM A135.
2. Joints: Mechanically coupled grooved.
3. Fittings: 500 lb. WOG, black, malleable iron, ASTM A47.
4. Plain end fittings and couplings are not acceptable.

C. Fire Protection Service to Building

1. Refer to civil plans and plumbing plans.

2.2 FLEXIBLE SPRINKLER HOSE WITH THREADED END FITTINGS

A. UL listed per UL 2443.

B. Construction:

1. Hose:
   a. Type 304 stainless steel.
   b. Straight or elbow hose - maximum six (6)-foot hose length.
   c. 1/2" or 3/4" outlet.

d. 175 psi rated pressure.
e. Leak-tested minimum 7/8".
f. Minimum 7/8" hose.
g. O-ring sealed joints are not acceptable.

2. Ceiling Bracket:

a. Zinc plated or galvanized steel – 24" and 48" sizes.
b. Flexible hose attachment: Open hub or set screw.

3. Unit may be prepackaged with sprinkler head.

C. Acceptable Manufacturers: FlexHead Industries, Victaulic Aquaflex.

2.3 UNIONS AND COUPLINGS

A. Unions: 175 psi malleable iron for threaded ferrous piping.

B. Mechanical Grooved Couplings: Malleable iron housing clamps to engage and lock, designed to permit some angular and longitudinal deflection; "C" shaped composition sealing gasket, steel bolts, nuts, and washers. 175 psi, ASTM A47. Plain end fittings and couplings are not acceptable. Rolled groove couplings for Schedule 10 pipe. Cut groove couplings for Schedule 40 pipe. Couplings shall be enamel coated for wet systems. Acceptable Manufacturers: Victaulic, ITT, Grinnell, Central, Anvil GruvLok, Star Fittings.

C. Couplings used in seismic areas shall be "flexible" type.

D. Coupling gaskets for wet systems shall be Grade "E" EDPM Type A.

2.4 VALVE OPERATORS

A. Provide handwheels for gate valves. Provide gear operators for butterfly valves.

2.5 VALVE CONNECTIONS

A. Provide all connections to match pipe joints. Valves shall be same size as pipe.

2.6 BACKFLOW PREVENTERS

A. Provide backflow preventers as required by code and as specified on the drawings.

2.7 EQUIPMENT

A. Equipment shall be as scheduled on the drawings.

PART 3 - EXECUTION

3.1 INSTALLATION - PIPING

A. General Installation Requirements:

1. Coordinate piping and sprinkler locations with all other trades. Ductwork, diffusers and light fixture locations shall have priority over sprinkler piping and sprinklers.

2. Ream pipe and tube ends to full inside diameter. Remove burrs. Remove scale and foreign material, inside and outside, before assembly.

3. Die cut screw joints with full cut standard taper pipe threads.

4. Coat threads with pipe joint compound or wrap with Teflon tape.

5. Locate piping to minimize obstruction of other work.

6. Route piping in concealed spaces above finished ceiling.

7. Use full and double lengths of pipe wherever possible.

8. Slope all piping for complete drainage. Install auxiliary drains for all trapped piping per NFPA 13.

9. Reducers are generally not shown. Where pipe sizes change at tee, the tee shall be the size of the largest pipe shown connecting to it.

10. Comply with manufacturer's installation instructions.

B. Steel Piping:

1. In steel piping, main sized saddle branch connections or direct connection of branches to main is permitted if main is one pipe size larger than the branch for up to 6" mains and if main is two pipe sizes larger than branch for 8" and larger mains. Do not project branch pipes into main pipes.

C. Wall/Floor Penetration:

1. Provide sleeves when penetrating floors and walls.

2. Seal pipes passing through exterior walls with a wall seal per Section 21 05 29. Provide Schedule 40 galvanized sleeve at least 2 pipe sizes larger than the pipe. Sleeves through floors shall extend minimum 1.5" above finished floor.

3. Fire seal all pipe and sleeve penetrations (both wall and floor) to maintain fire separation required without restraining pipe.

D. Installation Requirements in Electrical Rooms:

1. Do not install piping or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the equipment. Fire protection equipment dedicated to the electrical equipment room or space may be installed above equipment if other alternatives are not available.

E. Hangers and Supports:

1. Provide hangers and supports as required by NFPA 13 and UL, with the following exceptions:

a. Do not use powder driven devices, explosive devices, wooden plugs, or plastic inserts.

b. Do not install fasteners to carry the load in tension, unless absolutely necessary.

F. Exposed Piping:

1. Install chrome plated steel escutcheons where exposed pipes penetrate walls or floors.

3.2 INSTALLATION - VALVES

A. Install gate valves with stems upright or horizontal, not inverted.

B. Backflow Preventer:

1. Units shall be field tested and tagged in accordance with manufacturer's instructions by a certified tester before initial operation.

2. Install unit between 12" and 60" above finish floor.

C. Shutoff Valve:

1. Install buried shutoff valves in valve boxes. Provide post indicators.

2. Provide drain valves at main shutoff valves, low points of piping and apparatus.

3.3 INSTALLATION - EQUIPMENT

A. Coordinate piping and sprinkler locations with all other trades. Ductwork, diffusers and light fixture locations shall have priority over system equipment and sprinklers.

B. Fire Department Connection:

1. Locate fire department connection in an accessible location as approved by the local fire department with sufficient clearance from walls, obstructions, and adjacent Siamese connectors to allow full swing of fire department wrench handle.

C. Horn and Strobe:

1. Locate outside horn and strobe on building wall as shown on drawings.

2. Wire all horn and strobes, flow switches and supervisory switches to fire alarm system. All wiring shall be in conduit and meet the requirements of the electrical specifications.

D. Test Valves:

1. Install test valves where required. Pipe to outdoors or drain. Test connection shall have flow equivalent to the smallest K-factor sprinkler.

E. Sprinklers:

1. Locate sprinklers to clear lights, ducts and diffusers. Do not run sprinkler pipes through ducts. Ductwork has priority over sprinkler pipes. Offset pipes as needed.

2. Center sprinklers in two directions in ceiling tiles and provide offsets as required.

3. Do not allow concealed sprinkler cover plates to be painted. Sprinkler cover plates are to be factory painted only. Do not field paint.

4. Apply strippable or paper covers so concealed sprinkler cover plates do not receive field paint finish.

3.4 SYSTEMS CLEANING AND TESTING

A. General Requirement:

1. All water used for testing and remaining in the piping system shall be obtained from a potable water source.

B. Underground Piping:

1. Flush all underground piping with minimum flow equal to the system design flow but not less than the following:

   a. 390 gpm for 4" pipes.
   b. 880 gpm for 6" pipes.
   c. 1560 gpm for 8" pipes.
   d. 2440 gpm for 10" pipes.

2. Branches from existing or new underground mains to sprinkler risers shall be flushed out through two 2-1/2" hoses (with flow through open hose butts) attached to the riser with 4" temporary piping. Flushing through the drain of an alarm check or dry pipe valve is not acceptable.

C. Interior Piping:

1. Verify adequate water flow at the inspector's test connection.

2. Flush all interior piping to remove scale and other foreign material before placing system into service.

3. Hydrostatically test the entire interior piping system at a minimum of 200 psig or 50 psig in excess of the normal system working pressure for systems subjected to pressures in excess of 150 psig. Maintain test pressure for 2 hours without loss of pressure.

D. Fire Alarm System:

1. Test the alarm system by operating the inspector's test connection or the alarm test valves. Verify that the building fire alarm system activates.

2. Adjust all monitor switches for proper operation.

END OF SECTION

SECTION 22 05 00
BASIC PLUMBING REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Requirements applicable to all Division 22 Sections. Also refer to Division 1 - General Requirements.

B. All materials and installation methods shall conform to the applicable standards, guidelines and codes referenced in the specification section.

1.2 DIVISION OF WORK BETWEEN MECHANICAL, ELECTRICAL & CONTROL CONTRACTORS

A. Definitions:

1. "Mechanical Contractors" refers to the following:

   a. Plumbing Contractor.
   b. Heating Contractor.
   c. Air Conditioning and Ventilating Contractor.
   d. Temperature Control Contractor.
   e. Fire Protection Contractor.
   f. Testing, Adjusting, and Balancing Contractor.

2. Motor Control Wiring: The wiring associated with the remote operation of the magnetic coils of magnetic motor starters or relays, or the wiring that permits direct cycling of motors by means of devices in series with the motor power wiring. In the latter case the devices are usually single phase and are usually connected to the motor power wiring through a manual motor starter having "Manual-Off-Auto" provisions.

3. Control devices such as start-stop push buttons, thermostats, pressure switches, flow switches, relays, etc., generally represent the types of equipment associated with motor control wiring.

4. Motor control wiring is single phase and usually 120 volts. In some instances, the voltage will be the same as the motor power wiring. Generally, where the motor power wiring exceeds 120 volts, a control transformer is used to give a control voltage of 120 volts.

5. Temperature Control Wiring: The wiring associated with the operation of a motorized damper, solenoid valve or motorized valve, etc., either modulating or two-position, as opposed to wiring which directly powers or controls a motor used to drive equipment such as fans, pumps, etc.

   a. This wiring will be from a 120 volt source and may continue as 120 volt, or be reduced in voltage (24 volt) in which case a control transformer shall be furnished as part of the temperature control wiring.

6. Control Motor: An electric device used to operate dampers, valves, etc. It may be two-position or modulating. Conventional characteristics of such a motor are 24 volts, 60 cycles, 1 phase, although other voltages may be encountered.

B. General:

1. The purpose of these Specifications is to outline the Electrical and Mechanical Contractor's responsibilities related to electrical work required for items such as temperature controls, mechanical equipment, fans, chillers, compressors and the like. The exact wiring requirements for much of the equipment cannot be determined until the systems have been selected and submittals reviewed. Therefore, the electrical drawings show only known wiring related to such items. All wiring not shown on the electrical drawings, but required for mechanical systems, is the responsibility of the Mechanical Contractor.

2. Where the drawings require the Electrical Contractor to wire between equipment furnished by the Mechanical Contractor, such wiring shall terminate at terminals provided in the equipment. The Mechanical Contractor shall provide complete wiring diagrams and supervision to the Electrical Contractor and designate the terminal numbers for correct wiring.

3. All electrical work shall conform to the National Electrical Code. All provisions of the Electrical Specifications concerning wiring, protection, etc., apply to wiring provided by the Mechanical Contractor unless noted otherwise.

C. Mechanical Contractor's Responsibility:

1. Assumes responsibility for internal wiring of all equipment provided by the Mechanical Contractor, for example:

   a. Burners.
   b. Condensing Units.
   c. Makeup Air Units.
   d. Gas Trains.
   e. Air Handling Units.

2. Assumes all responsibility for the Temperature Control wiring, when the Temperature Control Contractor is a Subcontractor to the Mechanical Contractor.

3. Temperature Control Subcontractor's Responsibility:

   a. Wiring of all devices needed to make the Temperature Control System functional.

   b. Verifying any control wiring on the electrical drawings as being by the Electrical Contractor. All wiring required for the Control System, but not shown on the electrical drawings, is the responsibility of the Temperature Control Subcontractor.

   c. Coordinating equipment locations (such as relays, transformers, etc.) with the Electrical Contractor, where wiring of the equipment is by the Electrical Contractor.

4. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

D. Electrical Contractor's Responsibility:

1. Provides all combination starters, manual starters and disconnect devices shown on the Electrical Drawings or indicated to be by the Electrical Contractor on the Mechanical Drawings or Specifications.

2. Installs and wires all remote control devices furnished by the Mechanical Contractor or Temperature Control Subcontractor when so noted on the Electrical Drawings.

3. Provides motor control and temperature control wiring, where so noted on the drawings.

4. Furnishes, installs and connects all relays, etc., for automatic shutdown of certain fans upon actuation of the Fire Alarm System as indicated and specified in Division 28.

5. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

1.3 COORDINATION DRAWINGS

A. Definitions:

1. Coordination Drawings: A compilation of the pertinent layout and system drawings that show the sizes and locations, including elevations, of system components and required access areas to ensure that no two objects will occupy the same space.

   a. Mechanical trades shall include, but are not limited to, mechanical equipment, ductwork, fire protection systems, plumbing piping, hydronic piping, and any item that may impact coordination with other disciplines.

   b. Electrical trades shall include, but are not limited to, electrical equipment, conduit 1.5" and larger, conduit racks, cable trays, pull boxes, transformers, raceway, busway, lighting, ceiling-mounted devices, and any item that may impact coordination with other disciplines.

   c. Technology trades shall include, but are not limited to, technology equipment, racks, conduit 1.5" and larger, conduit racks, cable trays, ladder rack, pull boxes, raceway, ceiling-mounted devices, and any item that may impact coordination with other disciplines.

   d. Maintenance clearances and code-required dedicated space shall be included.

   e. The coordination drawings shall include all underground, underfloor, in-floor, in chase, and vertical trade items.

2. The contractors shall use the coordination process to identify the proper sequence of installation of all utilities above ceilings and in other congested areas, to ensure an orderly and coordinated end result, and to provide adequate access for service and maintenance.

B. Participation:

1. The contractors and subcontractors responsible for work defined above shall participate in the coordination drawing process.

2. One contractor shall be designated as the Coordinating Contractor for purposes of preparing a complete set of composite electronic CAD coordination drawings that include all applicable trades, and for coordinating the activities related to this process. The Coordinating Contractor for this project shall be the HVAC Contractor.

   a. The Coordinating Contractor shall utilize personnel familiar with requirements of this project and skilled as draftspersons/CAD operators, competent to prepare the required coordination drawings.

3. Electronic CAD drawings shall be submitted to the Coordinating Contractor for addition of work by other trades. KJWW will provide electronic file copies of ventilation drawings for contractor's use if the contractor signs and returns an "Electronic File Transfer" waiver provided by KJWW. KJWW will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings.

C. General:

1. Coordination drawing files shall be made available to the A/E and Owner's Representative. The A/E will only review identified conflicts and give an opinion, but will not perform as a coordinator.

2. A plotted set of coordination drawings shall be available at the project site.

3. Coordination drawings are not shop drawings and shall not be submitted as such.

4. The contract drawings are schematic in nature and do not show every fitting and appurtenance for each utility. Each contractor is expected to have included in his/her bid sufficient fittings, material, and labor to allow for adjustments in routing of utilities made necessary by the coordination process and to provide a complete and functional system.

5. The contractors will not be allowed additional costs or time extensions due to participation in the coordination process.

6. The contractors will not be allowed additional costs or time extensions for additional fittings, reroutings or changes of duct size, that are essentially equivalent sizes to those shown on the drawings and determined necessary through the coordination process.

7. The A/E reserves the right to determine space priority of equipment in the event of spatial conflicts or interference between equipment, piping, conduit, ducts, and equipment provided by the trades.

8. Changes to the contract documents that are necessary for systems installation and coordination shall be brought to the attention of the A/E.

9. Access panels shall preferably occur only in gypsum board walls or plaster ceilings where indicated on the drawings.

   a. Access to mechanical, electrical, technology, and other items located above the ceiling shall be through accessible lay-in ceiling tile areas.

   b. Potential layout changes shall be made to avoid additional access panels.

   c. Additional access panels shall not be allowed without written approval from the A/E at the coordination drawing stage.

   d. Providing additional access panels shall be considered after other alternatives are reviewed and discarded by the A/E and the Owner's Representative.

   e. When additional access panels are required, they shall be provided without additional cost to the Owner.

10. Complete the coordination drawing process and obtain sign off of the drawings by all contractors prior to installing any of the components.

11. Conflicts that result after the coordination drawings are signed off shall be the responsibility of the contractor or subcontractor who did not properly identify their work requirements, or installed their work without proper coordination.

12. Updated coordination drawings that reflect as-built conditions may be used as record documents.

1.4 QUALITY ASSURANCE

A. Contractor’s Responsibility Prior to Submitting Pricing Data:

1. The Contractor is responsible for constructing complete and operating systems. The Contractor acknowledges and understands that the Contract Documents are a two-dimensional representation of a three-dimensional object, subject to human interpretation. This representation may include imperfect data, interpreted codes, utility guidelines, three-dimensional conflicts, and required field coordination items. Such deficiencies can be corrected when identified prior to ordering material and starting installation. The Contractor agrees to carefully study and compare the individual Contract Documents and report at once in writing to the Design Team any deficiencies the Contractor may discover. The Contractor further agrees to require each subcontractor to likewise study the documents and report at once any deficiencies discovered.

2. The Contractor shall resolve all reported deficiencies with the Architect/Engineer prior to awarding any subcontracts, ordering material, or starting any work with the Contractor's own employees. Any work performed prior to receipt of instructions from the Design Team will be done at the Contractor's risk.

B. Qualifications:

1. Only products of reputable manufacturers are acceptable.

2. All Contractors and subcontractors shall employ only workers skilled in their trades.

C. Compliance with Codes, Laws, Ordinances:

1. Conform to all requirements of the City of Madison, Wisconsin Codes, Laws, Ordinances and other regulations having jurisdiction.

2. Conform to all State Codes.

3. Conform to Federal Act S.3874 requiring the reduction of lead in drinking water.

4. If there is a discrepancy between the codes and regulations and these specifications, the Architect/Engineer shall determine the method or equipment used.

5. If the Contractor notes, at the time of bidding, any parts of the drawings or specifications that do not comply with the codes or regulations, he shall inform the Architect/Engineer in writing, requesting a clarification. If there is insufficient time for this procedure, he shall submit with his proposal a separate price to make the system comply with the codes and regulations.

6. All changes to the system made after letting of the contract, to comply with codes or requirements of Inspectors, shall be made by the Contractor without cost to the Owner.

7. If there is a discrepancy between manufacturer's recommendations and these specifications, the manufacturer's recommendations shall govern.

8. All rotating shafts and/or equipment shall be completely guarded from all contact. Partial guards and/or guards that do not meet all applicable OSHA standards are not acceptable. Contractor is responsible for providing this guarding if it is not provided with the equipment supplied.

D. Permits, Fees, Taxes, Inspections:

1. Procure all applicable permits and licenses.

2. Abide by all laws, regulations, ordinances, and other rules of the State or Political Subdivision where the work is done, or as required by any duly constituted public authority.

3. Pay all charges for permits or licenses.

4. Pay all fees and taxes imposed by the State, Municipal and/or other regulatory bodies.

5. Pay all charges arising out of required inspections by an authorized body.

6. Pay all charges arising out of required contract document reviews associated with the project and as initiated by the Owner or authorized agency/consultant.

7. Where applicable, all fixtures, equipment and materials shall be approved or listed by Underwriter's Laboratories, Inc.

E. Examination of Drawings:

1. The drawings for the plumbing work are completely diagrammatic, intended to convey the scope of the work and to indicate the general arrangements and locations of equipment, outlets, etc., and the approximate sizes of equipment.

2. Contractor shall determine the exact locations of equipment and rough-ins, and the exact routing of pipes and ducts to best fit the layout of the job.

3. Scaling of the drawings is not sufficient or accurate for determining these locations.

4. Where job conditions require reasonable changes in indicated arrangements and locations, such changes shall be made by the Contractor at no additional cost to the Owner.

5. Because of the scale of the drawings, certain basic items, such as fittings, boxes, valves, unions, etc., may not be shown, but where required by other sections of the specifications or required for proper installation of the work, such items shall be furnished and installed.

6. If an item is either on the drawings or in the specifications, it shall be included in this contract.

7. Determination of quantities of material and equipment required shall be made by the Contractor from the documents. Where discrepancies arise between drawings, schedules and/or specifications, the greater number shall govern.

8. Where used in mechanical documents, the word "furnish" shall mean supply for use, the word "install" shall mean connect complete and ready for operation, and the word "provide" shall mean to supply for use and connect complete and ready for operation.

   a. Any item listed as furnished shall also be installed, unless otherwise noted.

   b. Any item listed as installed shall also be furnished, unless otherwise noted.

F. Field Measurements:

1. Verify all pertinent dimensions at the job site before ordering any materials or fabricating any supports, pipes or ducts.

G. Electronic Media/Files:

1. Construction drawings for this project have been prepared utilizing Revit.

2. Contractors and Subcontractors may request electronic media files of the contract drawings and/or copies of the specifications. Specifications will be provided in PDF format.

3. Upon request for electronic media, the Contractor shall complete and return a signed “Electronic File Transmittal” form provided by KJWW.

4. If the information requested includes floor plans prepared by others, the Contractor will be responsible for obtaining approval from the appropriate Design Professional for use of that part of the document.

5. The electronic contract documents can be used for preparation of shop drawings and as-built drawings only. The information may not be used in whole or in part for any other project.

6. The drawings prepared by KJWW for bidding purposes may not be used directly for coordination drawings.

7. The use of these electronic files by the Contractor does not relieve them from their responsibility for coordination of work with other trades and verification of space available for the installation.

8. The information is provided to expedite the project and assist the Contractor with no guarantee by KJWW as to the accuracy or correctness of the information provided. KJWW accepts no responsibility or liability for the Contractor's use of these documents.

1.5 SUBMITTALS

A. Submittals shall be required for the following items, and for additional items where required elsewhere in the specifications or on the drawings.

1. Submittals List:

Referenced Specification Section	Submittal Item
22 30 00	Water Softeners
22 33 39	Solar Water Heating Systems
Refer to drawings	Plumbing Material List Items

B. General Submittal Procedures: In addition to the provisions of Division 1, the following are required:

1. Transmittal: Each transmittal shall include the following:

   a. Date
   b. Project title and number
   c. Contractor's name and address
   d. Division of work (e.g., plumbing, heating, ventilating, etc.)
   e. Description of items submitted and relevant specification number
   f. Notations of deviations from the contract documents
   g. Other pertinent data

2. Submittal Cover Sheet: Each submittal shall include a cover sheet containing:

   a. Date
   b. Project title and number
   c. Architect/Engineer
   d. Contractor and subcontractors' names and addresses
   e. Supplier and manufacturer's names and addresses
   f. Division of work (e.g., plumbing, heating, ventilating, etc.)
   g. Description of item submitted (using project nomenclature) and relevant specification number
   h. Notations of deviations from the contract documents
   i. Other pertinent data
   j. Provide space for Contractor's review stamps

3. Composition:

   a. Submittals shall be submitted using specification sections and the project nomenclature for each item.

   b. Individual submittal packages shall be prepared for items in each specification section. All items within a single specification section shall be packaged together where possible. An individual submittal may contain items from multiple specifications sections if the items are intimately linked (e.g., pumps and motors).

   c. All sets shall contain an index of the items enclosed with a general topic description on the cover.

4. Content: Submittals shall include all fabrication, erection, layout, and setting drawings; manufacturers' standard drawings; schedules; descriptive literature, catalogs and brochures; performance and test data; wiring and control diagrams; dimensions; shipping and operating weights; shipping splits; service clearances; and all other drawings and descriptive data of materials of construction as may be required to show that the materials, equipment or systems and the location thereof conform to the requirements of the contract documents.

5. Contractor's Approval Stamp:

   a. The Contractor shall thoroughly review and approve all shop drawings before submitting them to the Architect/Engineer. The Contractor shall stamp, date and sign each submittal certifying it has been reviewed.

   b. Unstamped submittals will be rejected.

   c. The Contractor's review shall include, but not be limited to, verification of the following:

      1) Only approved manufacturers are used.
      2) Addenda items have been incorporated.
      3) Catalog numbers and options match those specified.
      4) Performance data matches that specified.
      5) Electrical characteristics and loads match those specified.
      6) Equipment connection locations, sizes, capacities, etc. have been coordinated with other affected trades.
      7) Dimensions and service clearances are suitable for the intended location.
      8) Equipment dimensions are coordinated with support steel, housekeeping pads, openings, etc.
      9) Constructability issues are resolved (e.g., weights and dimensions are suitable for getting the item into the building and into place, sinks fit into countertops, etc.).

   d. The Contractor shall review, stamp and approve all subcontractors' submittals as described above.

   e. **The Contractor's approval stamp is required on all submittals. Approval will indicate the Contractor's review of all material and a complete understanding of exactly what is to be furnished. Contractor shall clearly mark all deviations from the contract documents on all submittals. If deviations are not marked by the Contractor, then the item shall be required to meet all drawing and specification requirements.**

6. Submittal Identification and Markings:

   a. The Contractor shall clearly mark each item with the same nomenclature applied on the drawings or in the specifications.

   b. The Contractor shall clearly indicate the size, finish, material, etc.

   c. Where more than one model is shown on a manufacturer's sheet, the Contractor shall clearly indicate exactly which item and which data is intended.

   d. All marks and identifications on the submittals shall be unambiguous.

7. Schedule submittals to expedite the project. Coordinate submission of related items.

8. Identify variations from the contract documents and product or system limitations that may be detrimental to the successful performance of the completed work.

9. Reproduction of contract documents alone is not acceptable for submittals.

10. Incomplete submittals will be rejected without review. Partial submittals will only be reviewed with prior approval from the Architect/Engineer.

11. Submittals not required by the contract documents may be returned without review.

12. The Architect/Engineer's responsibility shall be to review one set of shop drawing submittals for each product. If the first submittal is incomplete or does not comply with the drawings and/or specifications, the Contractor shall be responsible to bear the cost for the Architect/Engineer to recheck and handle the additional shop drawing submittals.

13. Submittals shall be reviewed and approved by the Architect/Engineer **before** releasing any equipment for manufacture or shipment.

14. Contractor's responsibility for errors, omissions or deviation from the contract documents in submittals is not relieved by the Architect/Engineer's approval.

C. Electronic Submittal Procedures:

1. Distribution: Email submittals as attachments to all parties designated by the Architect/Engineer, unless a web-based submittal program is used.

2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.

3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.

4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

   a. Submittal file name: 22 XX XX.description.YYYYMMDD
   b. Transmittal file name: 22 XX XX.description.YYYYMMDD

5. File Size: Electronic file size shall be limited to a maximum of 4MB. Larger files shall be transmitted via a pre-approved method.

1.6 PRODUCT DELIVERY, STORAGE, HANDLING & MAINTENANCE

A. Exercise care in transporting and handling to avoid damage to materials. Store materials on the site to prevent damage. Keep materials clean, dry and free from harmful conditions. Immediately remove any materials that become wet or that are suspected of becoming contaminated with mold or other organisms.

B. Keep all bearings properly lubricated and all belts properly tensioned and aligned.

C. Coordinate the installation of heavy and large equipment with the General Contractor and/or Owner. If the Mechanical Contractor does not have prior documented experience in rigging and lifting similar equipment, he/she shall contract with a qualified lifting and rigging service that has similar documented experience. Follow all equipment lifting and support guidelines for handling and moving.

D. Contractor is responsible for moving equipment into the building and/or site. Contractor shall review site prior to bid for path locations and any required building modifications to allow movement of equipment. Contractor shall coordinate his/her work with other trades.

1.7 WARRANTY

A. Refer to Division 01 specification for requirements.

1.8 INSURANCE

A. Contractor shall maintain insurance coverage as set forth in Division 0 of these specifications.

1.9 MATERIAL SUBSTITUTION

A. Refer to Division 01 specification for requirements.

1.10 LEED REQUIREMENTS

A. This project is pursuing a LEED Silver certification in accordance with USGBC LEED Rating System for New Construction Version 2009. The Contractor shall provide all services and documentation necessary to achieve this rating.

B. Refer to Division 01 specification for LEED credits being attempted on the project.

1.11 PROJECT COMMISSIONING

A. The Contractor shall work with the Commissioning Agent (CxA) as described in Division 01 specifications, and provide all services necessary for compliance with LEED Prerequisite EAp1, Fundamental Commissioning, and EAc3 Enhanced Commissioning.

PART 2 - PRODUCTS

NOT APPLICABLE

PART 3 - EXECUTION

3.1 JOBSITE SAFETY

A. Neither the professional activities of the Architect/Engineer, nor the presence of the Architect/Engineer or his or her employee and subconsultants at a construction site, shall relieve the Contractor and other entity of their obligations, duties and responsibilities including, but not limited to, construction means, methods, sequence, techniques or procedures necessary for performing, superintending or coordinating all portions of the work of construction in accordance with the contract documents and any health or safety precautions required by any regulatory agencies. The Architect/Engineer and his or her personnel have no authority to exercise any control over any construction contractor or other entity or their employees in connection with their work or any health or safety precautions. The Contractor is solely responsible for jobsite safety. The Architect/Engineer and the Architect/Engineer's consultants shall be indemnified and shall be made additional insureds under the Contractor's general liability insurance policy.

3.2 EXCAVATION, FILL, BACKFILL, COMPACTION

A. General:

1. Prior to the commencement of any excavation or digging, the Contractor shall verify all underground utilities with the regional utility locator. Provide prior notice to the locator before excavations. Contact information for most regional utility locaters can be found by calling 811.

2. The Contractor shall do all excavating, filling, backfilling and compacting associated with his work.

B. Excavation:

1. Make all excavations to accurate, solid, undisturbed earth, and to proper dimensions.

2. Where excavations are made in error below foundations, concrete of same strength as specified for the foundations or thoroughly compacted sand-gravel fill, as determined by the Architect/Engineer, shall be placed in such excess excavations. Place thoroughly compacted, clean, stable fill in excess excavations under slabs on grade, at the Contractor's expense.

3. Trim bottom and sides of excavations to grades required for foundations.

4. Protect excavations against frost and freezing.

5. Take care in excavating not to damage surrounding structures, equipment or buried pipe. Do not undermine footing or foundation.

6. Perform all trenching in a manner to prevent cave-ins and risk to workmen.

7. Where original surface is pavement or concrete, the surface shall be saw cut to provide clean edges and assist in the surface restoration.

8. Where satisfactory bearing soil for foundations is not found at the indicated levels, the Architect/Engineer or their representative shall be notified immediately, and no further work shall be done until further instructions are given by the Architect/Engineer or their representative.

C. Dewatering:

1. Contractor shall furnish, install, operate and remove all dewatering pumps and pipes needed to keep trenches and pits free of water.

D. Underground Obstructions:

1. Known underground piping, foundations, and other obstructions in the vicinity of construction are shown on the drawings. Use great care in making installations near underground obstruction.

2. If objects not shown on the drawings are encountered, remove, relocate, or perform extra work as directed by the Architect/Engineer.

E. Fill and Backfilling:

1. Prior to backfilling all inspections and testing shall be completed.

2. No rubbish or waste material is permitted for fill or backfill.

3. Provide all necessary sand for backfilling.

4. Dispose of the excess excavated earth as directed.

5. Backfill materials shall be suitable for required compaction, clean and free of perishable materials and stones greater than 4 inches in diameter. Water shall not be permitted to rise in unbackfilled trenches. No material shall be used for backfilling that contains frozen earth, debris or earth with a high void content.

6. Backfill all trenches and excavations immediately after installing pipes, or removal of forms, unless other protection is provided.

7. Around piers and isolated foundations and structures, backfill and fill shall be placed and consolidated simultaneously on all sides to prevent wedge action and displacement. Fill and backfill materials shall be spread in 6 inch uniform horizontal layers with each layer compacted separately to required density.

8. Lay all piping on a compacted bed of sand at least 3 inches deep. Backfill around pipes with sand, 6 inch layers, and compact each layer.

9. Use sand for backfill up to grade for all piping under slabs or paved areas. All other piping shall have sand backfill to 6 inches above the top of the pipe.

10. Place all backfill above the sand in uniform layers not exceeding 6 inches deep. Each layer shall be placed, then carefully and uniformly tamped, to eliminate lateral or vertical displacement.

11. Where the fill and backfill will ultimately be under a building, floor or paving, each layer of fill shall be compacted to 95% of the maximum density determined by AASHTO Designation T-99 or ASTM Designation D-698. Moisture content of soil at time of compaction shall not exceed plus or minus 2% of optimum moisture content determined by AASHTO T-99 or ASTM D-698 test.

F. Surface Restoration:

1. Where trenches are cut through graded, planted or landscaped areas, the areas shall be restored to the original condition. Replace all planting removed or damaged to its original condition. A minimum of 6 inches of topsoil shall be applied where disturbed areas are to be seeded or sodded.

2. Concrete or asphalt type pavement, seal coat, rock, gravel or earth surfaces removed or damaged shall be replaced with comparable materials and restored to original condition.

3.3 OPERATION AND MAINTENANCE MANUALS

A. Refer to Division 01 specification for requirements.

3.4 INSTRUCTING THE OWNER'S REPRESENTATIVES

A. Adequately instruct the Owner's designated representatives in the maintenance, care, and operation of all systems installed under this contract per specification 01 79 00.

B. The instructions shall include:

1. Explanation of all system flow diagrams.

2. Maintenance of equipment.

3. Start-up procedures for all major equipment.

4. Description of emergency system operation.

C. Minimum hours of instruction for each item shall be:

1. Domestic Hot Water System - 1 hour.

2. Water Softener System - 1 hour.

3.5 SYSTEM COMMISSIONING

A. Refer to Division 01 91 00 specification for additional requirements.

B. The plumbing systems shall be complete and operating. System start-up, testing, balancing, and satisfactory system performance is the responsibility of the Contractor. This includes calibration and adjustments of all controls, noise level adjustments and final adjustments as required.

C. Contractor shall adjust the plumbing systems and controls at season changes during the one year warranty period, as required, to provide satisfactory operation and to prove performance of all systems in all seasons.

D. All operating conditions and control sequences shall be tested during the start-up period. Test all interlocks, safety shutdowns, controls, and alarms.

E. The Contractor, subcontractors, and equipment suppliers shall have skilled technicians to ensure that all systems perform properly. If the Architect/Engineer is requested to visit the job site for trouble shooting, assisting in start-up, obtaining satisfactory equipment operation, resolving installation and/or workmanship problems, equipment substitution issues or unsatisfactory system performance, including call backs during the warranty period, through no fault of the design; the Contractor shall reimburse the Owner on a time and materials basis for services rendered at the Architect/Engineer's standard hourly rates in effect when the services are requested. The Contractor shall pay the Owner for services required that are product, installation or workmanship related. Payment is due within 30 days after services are rendered.

3.6 RECORD DOCUMENTS

A. The following paragraph supplements Division 1 requirements:

Contractor shall maintain at the job site a separate and complete set of plumbing drawings and specifications on which he shall clearly and permanently mark in complete detail all changes made to the plumbing systems.

B. Mark drawings to indicate revisions to piping size and location, both exterior and interior; including locations devices, requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned from column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located; Change Orders; concealed control system devices.

C. Mark specifications to show approved substitutions; Change Orders, and actual equipment and materials used.

D. Record changes daily and keep the marked drawings available for the Architect/Engineer's examination at any normal work time.

E. Upon completing the job, and before final payment is made, give the marked-up drawings to the Architect/Engineer.

3.7 ADJUST AND CLEAN

A. Thoroughly clean all equipment and systems prior to the Owner's final acceptance of the project. Clean all foreign paint, grease, oil, dirt, labels, stickers, and other foreign material from all equipment.

B. Clean all areas where moisture is present. Immediately report any mold, biological growth, or water damage.

C. Remove all rubbish, debris, etc., accumulated during construction from the premises.

3.8 CONSTRUCTION WASTE MANAGEMENT

A. This Contractor shall comply with all construction and demolition waste disposal and recycling requirements outlined in LEED MRc2: Construction Waste Management (follow latest edition at the time of bidding or as referenced in these specifications).

1. This Contractor shall coordinate with the General Contractor to develop and implement a construction waste management plan that, at a minimum, identifies the materials to be diverted from disposal and whether the materials will be sorted on-site or co-mingled.

2. The Contractor shall track waste disposal and recycling efforts throughout the construction process for all materials associated with this Contractor’s scope of work. The Contractor shall provide this information to the General Contractor so that it can be incorporated with similar information from all other contractors for the project.

a. Calculations for waste and recycled material can be done by weight or volume, but they must be consistent throughout the project. The Contractor shall coordinate with the General Contractor to establish the preferred calculation method and report the results accordingly.

b. Excavated soil and land-clearing debris do not count towards the waste disposal or recycled material.

3. At a minimum, 50% of the construction and demolition debris for this project must be recycled or salvaged.

END OF SECTION

READINESS CERTIFICATION PRIOR TO FINAL JOBSITE OBSERVATION

In order to prevent the final job observation from occurring too early, we require that the Contractor review the completion status of the project and, by copy of this document, certify that the job is indeed ready for the final job observation. The following is a typical list of items that represent the degree of job completeness expected prior to your requesting a final job observation.

1. Penetrations fire sealed and labeled in accordance with specifications.
2. All pumps operating and balanced.
3. All plumbing fixtures installed and caulked.
4. Pipe insulation complete, pipes labeled and valves tagged.

Accepted by:

Prime Contractor _____

By _____ Date _____

Upon Contractor certification that the project is complete and ready for a final job observation, we require the Contractor to sign this agreement and return it to the Architect/Engineer so that the final observation can be scheduled.

It is understood that if the Architect/Engineer finds the job not ready for the final observation and that additional trips and observations are required to bring the project to completion, the costs incurred by the Architect/Engineers for additional time and expenses will be deducted from the Contractor's contract retainage prior to final payment at the completion of the job.

* * * * *

SECTION 22 05 29
PLUMBING SUPPORTS AND ANCHORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Hangers, Supports, and Associated Anchors.
B. Equipment Bases and Supports.
C. Sleeves and Seals.
D. Flashing and Sealing of Equipment and Pipe Stacks.
E. Cutting of Openings.
F. Escutcheon Plates and Trim.

1.2 REFERENCES

A. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.
B. MSS SP-127 – Bracing for Piping Systems Seismic-Wind-Dynamic Design, Selection, Application

1.3 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 22 05 00.

1.4 WORK FURNISHED BUT INSTALLED UNDER OTHER SECTIONS

A. Furnish sleeves and hanger inserts to General Contractor for placement into formwork.

PART 2 - PRODUCTS

2.1 SEISMIC RESTRAINTS

A. Refer to Section 22 05 50 for additional requirements for seismic restraints.

2.2 HANGER RODS

A. Hanger rods for single rod hangers shall conform to the following:

Pipe Size	Hanger Rod Diameter	
	Column #1	Column #2
2" and smaller	3/8"	3/8"
2-1/2" through 3-1/2"	1/2"	1/2"
4" and 5"	5/8"	1/2"
6"	3/4"	5/8"
8" through 12"	7/8"	3/4"

Column #1: Steel and cast iron pipe.
Column #2: Copper and plastic pipe.

B. Rods for double rod hangers may be reduced one size. Minimum rod diameter is 3/8 inches.

C. Hanger rods and accessories used in mechanical spaces or otherwise dry areas shall have ASTM B633 electro-plated zinc finish.

2.3 PIPE HANGERS AND SUPPORTS

A. All pipe hangers, clamps, and supports shall conform to Manufacturers Standardization Society MSS-SP-58 and 127 (where applicable).

B. Oversize all hangers, clamps, and supports on insulated piping to allow insulation and jacket to pass through unbroken. This applies to both hot and cold pipes.

C. Ferrous hot piping 2-1/2 inches and larger shall have steel saddles tack welded to the pipe at each support at a depth not less than the specified insulation. Factory fabricated inserts may be used.

Acceptable Products:

Anvil -	Fig. 160, 161, 162, 163, 164, 165
Cooper/B-Line -	Fig. 3160, 3161, 3162, 3163, 3164, 3165
Erico -	Model 630, 631, 632, 633, 634, 635
Nibco/Tolco -	Fig. 260-1, 261-1 1/2, 262-2, 263-2 1/2, 264-3, 265-4

D. On all insulated piping, provide a semi-cylindrical metallic shield and fire resistant vapor barrier jacket.

E. As an alternative to separate pipe insulation insert and saddle, properly sized integral rigid insulation sections may be used for this application.

Acceptable Products:

Cooper/B-Line -	Fig. B3380 through B3384
Pipe Shields -	A1000, A2000
Erico -	Model 124, 127

F. Support and laterally brace vertical pipes at every floor level in multi-story structures, and more frequently when required by applicable codes (the Illinois Plumbing Code requires 10 foot maximum spacing for support of copper risers), but never at intervals over 15 feet. Support vertical pipes with riser clamps installed below hubs, couplings or lugs welded to the pipe. Provide sufficient flexibility to accommodate expansion and contraction without compromising fire barrier penetrations and other fixed takeoff locations.

Acceptable Products:

Anvil -	Fig. CT121
Cooper/B-Line -	Fig. B3373CT
Erico -	Model 510
Nibco/Tolco -	Fig. 82

G. Place restrained neoprene mounts beneath vertical pipe riser clamps to prevent sweating of cold pipes. Insulate over mounts.

Acceptable Products: Mason RBA, RCA, or BR.

H. Hangers in direct contact with copper pipe shall be coated with plastic with appropriate temperature range. HYDRA-ZORB clamps are permitted for this application for bare pipes within their temperature limits of -65°F to +275°F.

I. Unless otherwise indicated, hangers shall be as follows:

1. Clevis Type:

Service:	Bare Metal Pipe
	Rigid Plastic Pipe
	Insulated Cold Pipe
	Insulated Hot Pipe - 3 inches & Smaller

Acceptable Products:	Bare Steel, Plastic or Insulated Pipe	Bare Copper Pipe
Anvil	Fig. 260	
Cooper/B-Line	Fig. 3100	Fig. B3100C
Erico	Model 400	
Nibco/Tolco	Fig. 1	Fig. 81PVC

2. Roller Type:
Service: Insulated Hot Pipe - 4 inches and Larger

Acceptable Products:	4" through 6"	8" and Above
Anvil	Fig. 181, 271	Fig. 171, 271
Cooper/B-Line	Fig. 3110, 3117	Fig. 3114, 3117
Erico	Model 610	Model 605
Nibco/Tolco	Fig. 324, 327	Fig. 322, 327

3. Padded Clevis Type:
Service: Glass Pipe

Acceptable Products:	Hangers	Pads
Anvil	Fig. 260	Fig. 3195
Cooper/B-Line	Fig. 3100	
Erico	Model 400	
Nibco/Tolco	Fig. 1	

4. Continuous Channel with Clevis Type:
Service: Plastic Tubing
Flexible Hose
Soft Copper Tubing

Acceptable Products:

Cooper/B-Line - Fig. B3106, with Fig. B3106V
Erico - Model 104, with Model 104V
Nibco/Tolco - Fig. 1V

5. Adjustable Swivel Ring Type:
Service: Bare Metal Pipe - 4 inches and Smaller

Acceptable Products:	Bare Steel Pipe	Bare Copper Pipe
Anvil	Fig. 69	
Cooper/B-Line	Fig. B3170NF	Fig. B3170CTC
Erico	Model FCN	102A0 Series
Nibco/Tolco	Fig. 200	Fig. 203

J. Support may be fabricated from U-Channel strut or similar shapes. Piping less than 4" in diameter shall be secured to strut with clamps of proper design and capacity as required to maintain spacing and alignment. Strut shall be independently supported from hanger drops or building structure. Size and support shall be per manufacturer's installation requirements for structural support of piping. Clamps shall not interrupt piping insulation.

1. Strut used in mechanical spaces or otherwise dry areas shall have ASTM B633 electro-plated zinc finish.

2. Strut used in damp areas listed in hanger rods shall have ASTM A123 hot-dip galvanized finish applied after fabrication.

K. Unless otherwise indicated, pipe supports for use with struts shall be as follows:

1. Clamp Type:

Service: Bare Metal Pipe
Rigid Plastic Pipe
Insulated Cold Pipe
Insulated Hot Pipe - 3 inches and smaller

a. Clamps in direct contact with copper pipe shall be plastic coated.

b. Pipes subject to expansion and contraction shall have clamps slightly oversized to allow limited pipe movement.

Acceptable Products:	Bare Steel, Plastic or Insulated Pipe	Bare Copper Pipe
Unistrut	Fig. P1100 or P2500	
Cooper/B-Line	Fig. B2000 or B2400	Fig. BVT
Nibco/Tolco	Fig. A-14 or 2STR	

2. Roller Type:

Service: Insulated Hot Pipe - 4 inches and larger.

Acceptable Products:	4" through 6"	8" and Above
Unistrut	Fig. P2474	Fig. P2474-1
Cooper/B-Line	Fig. B218	Fig. B219
Nibco/Tolco	Fig. ROL-12	Fig. ROL-13

L. Unless otherwise shown, upper attachments for hanger rods or support struts shall be as follows:

1. Beam Clamps:

Acceptable Products:	
Anvil	Fig. 228, 292
Cooper/B-Line	Fig. B3054
Erico	Model 360
Nibco/Tolco	Fig. 329

2. Concrete Inserts, Single Rod Galvanized:

Acceptable Products:	
Anvil	Fig. 282
Cooper/B-Line	Fig. B3014
Erico	Model 355
Nibco/Tolco	Fig. 310

3. Concrete Inserts, Continuous Strip Galvanized:

Acceptable Products:	
Unistrut Corp	P3200 Series
Cooper/B-Line	Fig. B22-J
Erico	CONCT

4. Concrete Anchors: Fasten to concrete using cast-in or post-installed anchors designed per the requirements of Appendix D of ACI 318-14. Post-installed anchors shall be qualified for use in cracked concrete by ACI-355.2.

5. Masonry Anchors: Fasten to concrete masonry units with expansion anchors or self-tapping masonry screws. For expansion anchors into hollow concrete block, use sleeve-type anchors designed for the specific application. Do not fasten in masonry joints. Do not use powder actuated fasteners, wooden plugs, or plastic inserts.

M. Copper piping located in an exposed area, including indirect waste piping in kitchens and janitors closets, shall use split ring standoff hangers for copper tubing. Support shall have copper electroplating for corrosion resistance. Use electro-galvanized or more corrosion resistant and threaded rod for floor applications. Use anchors applicable to the wall type with corrosion resistant threaded rod for wall applications.

Acceptable Products:	
Erico/M-Co	Model #456
B-Line	Fig. 3198HCT
Anvil	Fig. CT138R
Nibco/Tolco	Fig. 301CT

N. Wall supports shall be used where vertical height of structure exceeds minimum spacing requirements. Install wall supports at same spacing as hangers or strut supports along vertical length of pipe runs.

O. Welding:

1. Unless otherwise noted, hangers, clips, and auxiliary support steel may be welded in lieu of bolting, clamping, or riveting to the building structural frame. Take adequate precautions during all welding operations for fire prevention and for protecting walls and ceilings from being damaged by smoke.

2.4 FOUNDATIONS, BASES, AND SUPPORTS

A. Basic Requirements:

1. Furnish and install foundations, bases, and supports (not specifically indicated on the Drawings or in the Specifications of either the General Construction or Mechanical work as provided by another Contractor) for mechanical equipment.

2. All concrete foundations, bases and supports, shall be reinforced. All steel bases and supports shall receive a prime coat of zinc chromate or red metal primer. After completion of work, give steel supports a final coat of gray enamel.

B. Concrete Bases (Housekeeping Pads):

1. Refer to Section 22 05 50 for additional requirements for concrete bases in seismic applications.

2. Unless shown otherwise on the drawings, concrete bases shall be nominal 4 inches thick and shall extend 3 inches on all sides of the equipment (6 inches larger than factory base).

3. Where a base is less than 12 inches from a wall, extend the base to the wall to prevent a “dirt-trap”.

4. Concrete materials and workmanship required for the Contractor's work shall be provided by him. Materials and workmanship shall conform to the applicable standards of the Portland Cement Association. Reinforce with 6” x 6”, W1.4-W1.4 welded wire fabric. Concrete shall withstand 3,000 pounds compression per square inch at 28 days.

5. Equipment requiring bases is as follows:

a. Water Heater
b. Water Softener

C. Roof Pipe Supports:

1. Provide pre-fabricated roof pipe supports for all piping installed on the roof.

2. Support shall guide and align pipe while permitting longitudinal expansion.

3. The base shall be rounded to prevent damage to the roof, and drainage holes shall prevent ponding of water in the support.

4. Support shall be UV, corrosion and freeze/thaw resistant.

5. Support shall include orange paint, reflective safety orange accents or similar markings for increased visibility.

6. The strut system shall have galvanized aluminum finish.

7. Acceptable Products: Anvil International HBS-Base Series, Cooper B-Line Dura-Blok, Erico Caddy Pyramid 50, 150, 300, or 600 (to match load), Miro Industries 1.5, 3-R, 4-R or 5-R (to match pipe).

D. Supports:

1. Provide sufficient clips, inserts, hangers, racks, rods, and auxiliary steel to securely support all suspended material, equipment and conduit without sag.

2. Hang heavy equipment from concrete floors or ceilings with Architect/Engineer-approved concrete inserts, furnished and installed by the Contractor whose work requires them, except where indicated otherwise.

E. Grout:

1. Grout shall be non-shrinking premixed (Master Builders Company "Embecco"), unless otherwise indicated on the drawings or approved by the Architect/Engineer.

2. Use Mix No. 1 for clearances of 1" or less, and Mix No. 2 for all larger clearances.

3. Grout under equipment bases, around pipes, at pipe sleeves, etc., and where shown on the drawings.

2.5 OPENINGS IN FLOORS, WALLS AND CEILINGS

A. Exact locations of all openings for the installation of materials shall be determined by the Contractor and given to the General Contractor for installation or construction as the structure is built.

B. Coordinate all openings with other Contractors.

C. Hire the proper tradesman and furnish all labor, material and equipment to cut openings in or through existing structures, or openings in new structures that were not installed, or additional openings. Repair all spalling and damage to the satisfaction of the Architect/Engineer. Make saw cuts before breaking out concrete to ensure even and uniform opening edges.

D. Said cutting shall be at the complete expense of each Contractor. Failure to coordinate openings with other Contractors shall not exempt the Contractor from providing openings at his expense.

E. Do not cut structural members without written approval of the Architect or Structural Engineer.

2.6 ROOF PENETRATIONS

A. Seal pipes with surface temperature below 150ºF penetrating single-ply roofs with conical stepped pipe flashings and stainless steel clamps equal to Portals Plus Pipe Boots. Material shall match roofing membrane.

B. Break insulation only at the clamp for pipes between 60ºF and 150ºF. Seal outdoor insulation edges watertight.

2.7 PIPE SLEEVES AND LINTELS

A. Each Contractor shall provide pipe sleeves and lintels for all openings required for the Contractor's work in masonry walls and floors.

B. Fabricate all sleeves from standard weight black steel pipe or as indicated on the drawings. Provide continuous sleeve. Cut or split sleeves are not acceptable.

C. Fabricate all lintels for masonry walls from structural steel shapes or as indicated on the drawings. Have all lintels approved by the Architect or Structural Engineer.

D. Sleeves through the floors on exposed risers shall be flush with the ceiling, with planed squared ends extending 1" above the floor in unfinished areas, and flush with the floor in finished areas, to accept spring closing floor plates.

E. Sleeves shall not penetrate structural members or masonry walls without approval from the Structural Engineer. Sleeves shall then comply with the Architect/Engineer's design.

F. Openings through unexcavated floors and/or foundation walls below the floor shall have a smooth finish with sufficient annular space around material passing through opening so slight settling will not place stress on the material or building structure.

G. Install all sleeves concentric with pipes. Secure sleeves in concrete to wood forms. This Contractor is responsible for sleeves dislodged or moved when pouring concrete.

H. Where pipes rise through concrete floors that are on earthen grade, provide 3/4" resilient expansion joint material (asphalt and cork) wrapped around the pipe, the full depth of concrete, at the point of penetration. Secure to prevent shifting during concrete placement and finishing.

I. Size sleeves large enough to allow expansion and contraction movement. Provide continuous insulation wrapping.

2.8 ESCUTCHEON PLATES AND TRIM

A. Fit escutcheons to all insulated or uninsulated exposed pipes passing through walls, floors, or ceilings of finished rooms.

B. Escutcheons shall be heavy gauge, cold rolled steel, copper coated under a chromium plated finish, heavy spring clip, rigid hinge and latch.

C. Install galvanized steel (unless otherwise indicated) trim strip to cover vacant space and raw construction edges of all rectangular openings in finished rooms. This includes pipe openings.

2.9 PIPE PENETRATIONS

A. Seal all pipe penetrations. Seal non-rated walls and floor penetrations with grout or caulk. Backing material may be used.

B. Seal fire rated wall and floor penetrations with fire seal system as specified.

2.10 PIPE ANCHORS

A. Provide all items needed to allow adequate expansion and contraction of all piping. All piping shall be supported, guided, aligned, and anchored as required.

B. Repair all piping leaks and associated damage. Pipes shall not rub on any part of the building.

2.11 FINISH

A. Prime coat exposed steel hangers and supports. Hangers and supports in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

PART 3 - EXECUTION

3.1 PLUMBING SUPPORTS AND ANCHORS

A. General Installation Requirements:

1. Install all items per manufacturer's instructions.

2. Coordinate the location and method of support of piping systems with all installations under other Divisions and Sections of the Specifications.

3. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

B. Supports Requirements:

1. Install roof pipe supports to resist wind movement per manufacturer’s recommendations. Method of securing base to roof shall be compatible with roofing materials.

2. Where building structural steel is fireproofed, all hangers, clamps, auxiliary steel, etc., which attach to it shall be installed prior to application of fireproofing. Repair all fireproofing damaged during pipe installation.

3. Set all concrete inserts in place before pouring concrete.

4. Furnish, install and prime all auxiliary structural steel for support of piping systems.

5. Install hangers and supports complete with lock nuts, clamps, rods, bolts, couplings, swivels, inserts and required accessories.

6. Hangers for horizontal piping shall have adequate means of vertical adjustment for alignment.

C. Pipe Requirements:

1. Support all piping and equipment, including valves, strainers, traps and other specialties and accessories to avoid objectionable or excessive stress, deflection, swaying, sagging or vibration in the piping or building structure during erection, cleaning, testing and normal operation of the systems.

2. Do not, however, restrain piping to cause it to snake or buckle between supports or to prevent proper movement due to expansion and contraction.

3. Support piping at equipment and valves so they can be disconnected and removed without further supporting the piping.

4. Piping shall not introduce strains or distortion to connected equipment.

5. Parallel horizontal pipes may be supported on trapeze hangers made of structural shapes and hanger rods; otherwise, pipes shall be supported with individual hangers.

6. Trapeze hangers may be used where ducts interfere with normal pipe hanging.

7. Provide additional supports where pipe changes direction, adjacent to flanged valves and strainers, at equipment connections and heavy fittings.

8. Provide at least one hanger adjacent to each joint in cast iron soil pipe, grooved end steel pipe with mechanical couplings, and glass pipe.

D. Provided the installation complies with all loading requirements of truss and joist manufacturers, the following practices are acceptable:

1. Loads of 100 lbs.. or less may be attached anywhere along the top or bottom chords of trusses or joists with a minimum 3’ spacing between loads.

2. Loads greater than 100 lbs. must be hung concentrically and may be hung from top or bottom chord, provided one of the following conditions is met:

a. The hanger is attached within 6” from a web/chord joint.

b. Additional L2x2x1/4 web reinforcement is installed per manufacturer’s requirements.

3. It is prohibited to cantilever a load using an angle or other structural component that is attached to a truss or joist in such a fashion that a torsional force is applied to that structural member.

4. If conditions cannot be met, coordinate installation with truss or joist manufacturer and contact Architect/Engineer.

E. After piping and insulation installation are complete, cut hanger rods back at trapeze supports so they do not extend more than 3/4" below bottom face of lowest fastener and blunt any sharp edges.

F. Do not exceed 25 lbs. per hanger and a minimum spacing of 2’-0” on center when attaching to metal roof decking (limitation not required with concrete on metal deck). This 25 lbs. load and 2’-0” spacing include adjacent electrical and architectural items hanging from deck. If the hanger restrictions cannot be achieved, supplemental framing off steel framing will need to be added.

G. Do not exceed the manufacturer's recommended maximum load for any hanger or support.

H. Spacing of Hangers shall not exceed the compressive strength of the insulation inserts, and in no case shall exceed the following:

	Pipe Material	Maximum Spacing
1.	Steel (Std. Weight or Heavier – Liquid Service):	
	1-1/4" & under	7'-0"
	1-1/2"	9'-0"
	2"	10'-0"
	2-1/2"	11'-0"
	3"	12'-0"
	4" & larger	12'-0"
2.	Steel (Std. Weight or Heavier – Vapor Service):	
	1-1/4" and under	9'-0"
	1-1/2"	12'-0"
	2" & larger	12'-0"

	Pipe Material	Maximum Spacing
3.	Hard Drawn Copper & Brass (Liquid Service):	
	3/4" and under	5'-0"
	1"	6'-0"
	1-1/4"	7'-0"
	1-1/2"	8'-0"
	2"	8'-0"
	2-1/2"	9'-0"
	3"	10'-0"
	4"	12'-0"
	6"	12'-0"
4.	Hard Drawn Copper & Brass (Vapor Service):	
	3/4" & under	7'-0"
	1"	8'-0"
	1-1/4"	9'-0"
	1-1/2"	10'-0"
	2"	11'-0"
	2-1/2" & larger	12'-0"
5.	Cast Iron Soil Pipe - All Sizes:	
	Over 5' pipe lengths	10'-0"
	Less than 5' pipe lengths	5'-0"
	Support all direction changes and branch connections.	

6. Rigid Plastic Pipe:

   a. Space hangers at 4’-0” maximum centers.

7. Installation of hangers shall conform to MSS SP-58 and the applicable Plumbing Code.

END OF SECTION

SECTION 22 05 53
PLUMBING IDENTIFICATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Identification of products installed under Division 22.

1.2 SUBMITTALS

A. Submit shop drawings under provisions of Section 22 05 00. Include list of items identified, wording, letter sizes, and color coding.

B. Include valve chart and schedule listing valve tag number, location, function, and valve manufacturer's name and model number.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. 3M, Bunting, Calpico, Craftmark, Emedco, Kolbi Industries, Seton, W.H. Brady, Marking Services.

2.2 MATERIALS

A. All pipe markers (purchased or stenciled) shall conform to ANSI A13.1. Marker lengths and letter sizes shall be at least the following:

O.D. of Pipe or insulation	Marker Length	Size of Letters
Up to and including 1-1/4”	8”	1/2”
1-1/2” to 2”	8”	3/4”
2-1/2” to 6”	12”	1-1/4
8” to 10”	24”	2-1/2”
Over 10”	32”	3-1/2”

Plastic tags may be used for outside diameters under 3/4".

B. Plastic Nameplates: Laminated three-layer phenolic with engraved black, 1/4" minimum letters on light contrasting background.

C. Aluminum Nameplates: Black enamel background with natural aluminum border and engraved letters furnished with two mounting holes and screws.

D. Plastic Tags: Minimum 1-1/2" square or round laminated three-layer phenolic with engraved, 1/4" minimum black letters on light contrasting background.

E. Brass Tags: Brass background with engraved black letters. Tag size minimum 1-1/2" square or 1-1/2" round.

F. Plastic Pipe Markers: Semi-rigid plastic, preformed to fit around pipe or pipe covering; indicating flow direction and fluid conveyed.

G. Vinyl Pipe Markers: Colored vinyl with permanent pressure sensitive adhesive backing.

H. Stencil Painted Pipe Markers: Use industrial enamel spray paint per ANSI Standard A13.1. Indicate fluid conveyed and flow direction.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all products per manufacturer's recommendations.

B. Degrease and clean surfaces to receive adhesive for identification materials.

C. Valves:

1. All valves (except shutoff valves at equipment) shall have numbered tags.

2. Provide or replace numbered tags on all existing valves that are connected to new systems or that have been revised.

3. Provide all existing valves used to extend utilities to this project with numbered tags. Review tag numbering sequence with the Owner prior to ordering tags.

4. Secure tags with heavy duty key chain and brass "S" link or with mechanically fastened plastic straps.

5. Attach to handwheel or around valve stem. On lever operated valves, drill the lever to attach tags.

6. Number all tags and show the service of the pipe.

7. Provide two sets of laminated 8-1/2" x 11" copies of a valve directory listing all valves, with respective tag numbers, uses, and locations. The directory shall be reviewed by the Owner and Architect/Engineer prior to laminating final copies. Laminated copies shall have brass eyelet in at least one corner for easy hanging.

D. Pipe Markers:

1. Adhesive Backed Markers: Use Brady Style 1, 2, or 3 on pipes 3" diameter and larger. Use Brady Style 4, 6, or 8 on pipes under 3" diameter. Similar styles by other listed manufacturers are acceptable. Secure all markers at both ends with a wrap of pressure sensitive tape completely around the pipe.

2. Snap-on Markers: Use Seton "Setmark" on pipes up to 5-7/8" OD. Use Seton "Setmark" with nylon or Velcro ties for pipes 6" OD and over. Similar styles by other listed manufacturers are acceptable.

3. Stencil Painted Pipe Markers:

   a. Remove rust, grease, dirt, and all foreign substances from the pipe surface.
   b. Apply primer on non-insulated pipes before painting.
   c. Use background and letter colors as scheduled later in this section.

4. Apply markers and arrows in the following locations where clearly visible:

   a. At each valve.
   b. On both sides of walls that pipes penetrate.
   c. At least every 20 feet along all pipes.
   d. On each riser and each leg of each "T" joint.
   e. At least once in every room and each story traversed.

5. Underground Pipe Markers: Install 8" to 10" below grade, directly above buried pipes.

E. Equipment:

1. All equipment not easily identifiable such as controls, relays, gauges, etc.; and all equipment in an area remote from its function shall have nameplates or plastic tags listing name, function, and drawing symbol. Do not label exposed equipment in public areas.

2. Provide engraved plastic tags at all hydronic or steam system makeup water meters.

3. Mechanical equipment that is not covered by the U.S. National Appliance Energy Conservation Act (NAECA) of 1987 shall carry a permanent label installed by the manufacturer stating that the equipment complies with the requirements of ASHRAE 90.1.

3.2 SCHEDULE

A. Pipes to be marked shall be labeled with the text as shown in the following table regardless of which method or material is used:

Pipe Service	Lettering Color	Background Color
DOMESTIC COLD WATER	White	Green
DOMESTIC HOT WATER - 115°F	Black	Yellow
DOMESTIC HOT WATER CIRCULATING - 115°F	Black	Yellow
SANITARY SEWER	Black	Yellow
VENT	Black	Yellow
STORM SEWER (PRIMARY AND SECONDARY)	White	Green
NATURAL GAS	Black	Yellow

END OF SECTION

SECTION 22 07 19
PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Piping Insulation.
B. Insulation Jackets.

1.2 QUALITY ASSURANCE

A. Applicator: Company specializing in piping insulation application with five years minimum experience.

B. Materials: Flame spread/smoke developed rating of 25/50 in accordance with ASTM E84, NFPA 255, or UL 723 (where required).

C. In accordance with LEED EQc4.1, Low-Emitting Materials - Adhesives and Sealants, all adhesives and sealants used on the interior of the building must comply with the following requirements:

1. Adhesives, sealants and sealant primers must comply with South Coast Air Quality Management District (SCAQMD) Rule #1168.

2. Aerosol adhesives must comply with Green Seal Standard for Commercial Adhesives GS-36 requirements in effect on October 19, 2000.

1.3 SUBMITTALS

A. Submit shop drawings per Section 22 05 00. Include product description, list of materials and thickness for each service, and locations.

PART 2 - PRODUCTS

2.1 INSULATION

A. Type A: Glass fiber; ANSI/ASTM C547; 0.24 maximum 'K' value at 75ºF; non-combustible. All purpose, white kraft jacket bonded to aluminum foil and reinforced with fiberglass yarn, 25/50 flame spread/smoke developed rating when tested in accordance with ASTM E84 (UL 723).

B. Type B: Elastomeric cellular foam; ANSI/ASTM C534; flexible plastic; 0.27 maximum 'K' value at 75ºF, 25/50 flame spread/smoke developed rating when tested in accordance with ASTM E84 (UL 723). Maximum 3/4" thick per layer where multiple layers are specified.

C. Type C: Molded rigid cellular glass; ANSI/ASTM C-552; 0.35 maximum 'K' value at 75ºF; moisture resistant, non-combustible; suitable for -100ºF to +900ºF. For below grade installations use asphaltic mastic paper vapor barrier jacket. Use self-seal all-purpose white kraft jacket for above grade installations.

2.2 VAPOR BARRIER JACKETS

A. Kraft reinforced foil vapor barrier with self-sealing adhesive joints. Beach puncture resistance ratio of at least 50 units. Tensile strength: 35 psi minimum. Single, self-seal acrylic adhesive on longitudinal jacket laps and butt strips.

B. Polyvinylidene Chloride (PVDC or Saran) film and tape: Durable and highly moisture and moisture vapor resistant. Please refer to manufacturer's recommended installation guidelines.

2.3 JACKET COVERINGS

A. Plastic Jackets and Fitting Covers: High impact, glossy white, 0.030" thick, self-extinguishing plastic. Suitable for use indoors or outdoors with ultraviolet inhibitors. Suitable for -40ºF to 150ºF. 25/50 maximum flame spread/smoke developed.

PART 3 - EXECUTION

3.1 PREPARATION

A. Install insulation after piping has been tested. Pipe shall be clean, dry and free of rust before applying insulation.

3.2 INSTALLATION

A. General Installation Requirements:

1. Install materials per manufacturer's instructions, building codes and industry standards.

2. Continue insulation with vapor barrier through penetrations. This applies to all insulated piping. Maintain fire rating of all penetrations.

3. On all insulated piping, provide at each support an insert of same thickness and contour as adjoining insulation, between the pipe and insulation jacket, to prevent insulation from sagging and crushing. The insert shall be suitable for planned temperatures, be suitable for use with specific pipe material, and shall be a 180° cylindrical segment the same length as metal shields. Inserts shall be a cellular glass (for all temperature ranges) or molded hydrous calcium silicate (for pipe with operating temperatures above 70°F), with a minimum compressive strength of 50 psi. Factory fabricated inserts may be used. Rectangular blocks, plugs, or wood material are not acceptable. Temporary wood blocking may be used by the Piping Contractor for proper height; however, these must be removed and replaced with proper inserts by the Insulation Contractor.

4. Neatly finish insulation at supports, protrusions, and interruptions.

5. Install metal shields between all hangers or supports and the pipe insulation. Shields shall be galvanized sheet metal, half-round with flared edges. Adhere shields to insulation. On cold piping, seal the shields vapor-tight to the insulation as required to maintain the vapor barrier, or add separate vapor barrier jacket.

6. Shields shall be at least the following lengths and gauges:

	Pipe Size	Shield Size
a.	1/2" to 3-1/2"	12" long x 18 gauge
b.	4"	12" long x 16 gauge
c.	5” to 6"	18" long x 16 gauge
d.	8” to 14"	24" long x 14 gauge
e.	16” to 24"	24" long x 12 gauge

7. All piping and insulation that does not meet 25/50 that is located in an air plenum shall have written approval from the Authority Having Jurisdiction and the local fire department for authorization and materials approval. If approval has been allowed, the non-rated material shall be wrapped with a product that has passed ASTM E84 and/or NFPA 255 testing with a rating of 25/50 or below.

8. On 1" and smaller piping routed through metal wall studs, provide a plastic grommet to protect the piping. The piping shall be insulated between the wall studs, and the insulation shall butt up to each stud.

B. Insulated Piping Operating Below 60°F:

1. Insulate fittings, valves, unions, flanges, strainers, flexible connections, flexible hoses, and expansion joints. Seal all penetrations of vapor barrier.

2. On piping operating below 60ºF in locations that are not mechanically cooled (e.g., penthouses, mechanical rooms, tunnels, chases at exterior walls, etc.), Type B insulation shall be used.

3. All balance valves with fluid operating below 60°F shall be insulated with a removable plug wrapped with vapor barrier tape to allow reading and adjusting of the valve.

C. Insulated Piping Operating Between 60°F and 140°F:

1. Do not insulate flanges and unions, but bevel and seal ends of insulation at such locations. Insulate all fittings, valves and strainers.

D. Exposed Piping:

1. Locate and cover seams in least visible locations.

2. Where exposed insulated piping extends above the floor, provide a sheet metal guard around the insulation extending 12" above the floor. Guard shall be 0.016" cylindrical smooth or stucco aluminum and shall fit tightly to the insulation.

3. On exposed piping serving kitchen equipment or plumbing fixtures, the piping does not need to be insulated if less than four feet in developed length. If piping is longer than four feet in developed length, the piping shall be insulated and have a plastic jacket.

3.3 INSULATION

A. Type A Insulation:

1. All Service Jackets: Seal all longitudinal joints with self-seal laps using a single pressure sensitive adhesive system. Do not staple.

2. Insulation without self-seal lap may be used if installed with Benjamin Foster 85-20 or equivalent Chicago Mastic, 3M or Childers lap adhesive.

3. Apply insulation with laps on top of pipe.

4. Fittings, Valve Bodies and Flanges: For 4" and smaller pipes, insulate with 1 lb. density insulation wrapped under compression to a thickness equal to the adjacent pipe insulation. For pipes over 4", use mitered segments of pipe insulation. Finish with preformed plastic fitting covers. Secure fitting covers with pressure sensitive tape at each end. Overlap tape at least 2" on itself. For pipes operating below 60ºF, seal fitting covers with vapor retarder mastic in addition to tape.

B. Type B Insulation:

1. Elastomeric Cellular Foam: Where possible, slip insulation over the open end of pipe without slitting. Seal all butt ends, longitudinal seams, and fittings with adhesive. At elbows and tees, use mitered connections. Do not compress or crush insulation at cemented joints. Joints shall be sealed completely and not pucker or wrinkle. Paint the outside of outdoor insulation with two coats of latex enamel paint recommended by the manufacturer.

2. Self-seal insulation may be used on pipes operating below 170ºF.

C. Type C Insulation:

1. Seal all longitudinal joints with manufacturer approved adhesive. Secure butt joint strips in a similar manner.

2. Insulate fittings with prefabricated fittings.

3.4 JACKET COVER INSTALLATION

A. Plastic Covering:

1. Provide vapor barrier as specified for insulation type. Cover with plastic jacket covering. Position seams to shed water.

2. Solvent weld all joints with manufacturer recommended cement.

3. Overlap all laps and butt joints 1-1/2" minimum. Repair any loose ends that do not seal securely. Solvent weld all fitting covers in the same manner. Final installation shall be watertight.

4. All joints in areas noted shall meet USDA standards for Totally Sealed Systems, including overlaps of 1” on circumferential and 1.5” to 2” on longitudinal seams.

5. Use plastic insulation covering on all exposed pipes including, but not limited to:

   a. All exterior piping.
   b. All exposed piping below 8'-0" above floor.
   c. All piping in mechanical rooms and/or tunnels that is subject to damage from normal operations. (Example: Piping that must be stepped over routinely.)

3.5 SCHEDULE

	Piping System	Insulation Type/Thickness
A.	Domestic Hot Water & Circulating - Potable and Non-Potable - up to 140°F	
	Up to 1-1/2" Pipe Size	A / 1”
	Above 1-1/2" Pipe Size	A / 1-1/2”
B.	Domestic Cold Water - Potable and Non-Potable	B / 1”
C.	Plumbing Vents Within 10' from Roof Penetration	A / 1/2”
D.	Insulation Inserts at hangers	C - Match pipe insulation thickness

END OF SECTION

SECTION 22 09 00
INSTRUMENTATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Pressure Gauge.
B. Pressure Gauge Accessories.
C. Thermometers.
D. Test Plugs.

1.2 SUBMITTALS

A. Submit shop drawings per Section 22 05 00. Include list that indicates use, operating range, total range and location for manufactured components.

PART 2 - PRODUCTS

2.1 PRESSURE GAUGES

A. Gauges shall be 4-1/2" diameter with aluminum or stainless steel case with phosphor bronze bourdon tube, brass socket for water or oil application, 1/4" or 1/2" bottom connection. Gauges shall be 1% full scale accurate with bronze bushed brass movement and adjustable pointer. Standard ranges to be either pressure or pressure and vacuum as required of application.

B. Acceptable Manufacturers: Ashcroft, Marsh, Marshalltown, Miljoco, Trerice, U.S. Gauge Figure 1901, Weiss, Weksler, Wika.

2.2 PRESSURE GAUGE ACCESSORIES

A. All pressure gauges shall have valves and pressure snubbers. All pressure gauges on steam shall have pigtail syphon.

B. Shutoff Valve: 1/4" ball valve as specified for each piping system.

C. Pressure snubber, brass with 1/4" connections, porous metal type.

2.3 THERMOMETERS

A. Dial Type:

1. 4-1/2" diameter, hermetically sealed case. Stainless steel case and stem. Accuracy of 1% full scale with external recalibrator.

2. Select thermometers for appropriate temperature range. Adjustable elbow joint with locking device to allow rotation of thermometer to any angle.

3. Stem lengths as required for application with minimum insertion of 2-1/2".

4. Thermometers for water, steam, or oil shall have brass or steel separable socket. Socket shall extend through insulation.

5. Acceptable Manufacturer: Ashcroft, Marsh, Marshalltown, Miljoco, Tel-Tru, Trerice, U.S. Gauge, Weiss, Weksler, Wika.

B. Select scales to cover expected range of temperatures.

2.4 TEST PLUGS

A. Test Plug: 1/4" or 1/2" brass fitting and cap, with Nordel core for temperatures up to 275°F, for receiving 1/8" outside diameter pressure or temperature probe. Plugs shall be rated for zero leakage from vacuum to 500 psi.

B. Provide extended units for all plugs installed in insulated piping.

C. Test Kit: Carrying case, internally padded and fitted containing one 3-1/2" diameter pressure gauge with 0-100 psi range, one gauge adapter with 1/8" probes, two 1-1/2" dial thermometers with 0° to 220°F and -25°F to 125°F ranges and 5" stems.

D. Acceptable Manufacturers: Sisco, Flow Design, or Peterson Equipment.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install per manufacturer's instructions.

2. Coil and conceal excess capillary on remote element instruments.

3. Install gauges and thermometers in locations where they are easily read from normal operating level.

4. Do not install instrumentation when areas are under construction, except for required rough-in, taps, supports and test plugs.

B. Pressure Gauges:

1. Connect pressure gauges to suction and discharge side of all pumps.

2. Provide snubber for each pressure gauge.

3. Provide coil syphon for each pressure gauge connected to steam piping.

C. Thermometers:

1. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2" for installation of thermometer sockets.

2. Install thermometer sockets adjacent to control system thermostat, transmitter and sensor sockets.

END OF SECTION

SECTION 22 10 00
PLUMBING PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Pipe and Pipe Fittings.
B. Valves.
C. Domestic Water Piping System.
D. Sanitary Drainage and Vent Piping System.
E. Storm Drainage Piping System.

1.2 QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body. Remanufactured valves are not acceptable.

B. Welding Materials and Procedures: Conform to ASME Code and applicable state labor regulations.

C. Welders Certification: In accordance with ANSI/ASME Sec 9 or ANSI/AWS D1.1.

D. Piping, Fittings, Valves, and Flux for Potable Water Systems: All components shall be lead free per Federal Act S.3874, Reduction of Lead in Drinking Water Act.

1.3 SUBMITTALS

A. Submit shop drawings per Section 22 05 00.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store valves in shipping containers with labeling in place.

1.5 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 22 05 00 for required plumbing systems electronic CAD drawings to be provided to Coordinating Contractor for inclusion into composite coordination drawings.

PART 2 - PRODUCTS

2.1 COLD WATER - POTABLE AND NON-POTABLE
HOT WATER - POTABLE AND NON-POTABLE

A. Design Pressure: 175 psi.
Maximum Design Temperature: 200°F.

B. Piping - All Sizes:

1. Tubing: Type L hard drawn seamless copper tube, ASTM B88.

2. Joints: Solder with 100% lead-free solder and flux, ASTM B32.

3. Fittings: Wrought copper solder joint, ANSI B16.22.

C. Shutoff Valves:

1. Butterfly Valves:

a. BF-1:

1) 2-1/2" thru 6", 175 psi CWP, elastomers rated for 20°F to 250°F at 125 psig, fully lugged end, ductile or cast iron body (not in contact with fluid); bronze, aluminum-bronze or EPDM coated ductile iron disc; EPDM seat, stainless steel stem, extended neck, 175 psi bubble-tight, bi-directional dead-end shutoff without backing flange or nuts and with cap screws extending to centerline of valve body (for pipe extension without draining system), 10 position locking operator up to 6" size. Cv of at least 1580 in 6" size. Center Line Series 200, Keystone #222, Watts #DBF-03-121-1P, Stockham LD712-B&3-E, Nibco LD2000N Series, Milwaukee CL series, Hammond 5200 series.

2. Ball Valves:

a. BA-1:

1) 3" and under, 150 psi saturated steam, 600 psi CWP, full port, screwed or solder ends (acceptable only if rated for soldering in line with 470°F melting point of lead-free solder), bronze body of a copper alloy containing less than 15% zinc, stainless steel ball and trim, Teflon seats and seals. Apollo #77C-140, Stockham #S-255-FB-P-UL BR1-R, Milwaukee #BA-400, Watts, Nibco #585-70-66, National Utilities Co., RUB.

NOTES:

a) Provide extended shaft for all valves in insulated piping.

b) Provide lock out trim for all valves opening to atmosphere installed in domestic water piping over 120°F, heating water piping over 120°F, steam, condensate, boiler feed water piping, compressed air piping and gasoline/kerosene piping, and as indicated on the drawings. Solid extended shaft is not required on valves with lock out trim.

D. Check Valves:

1. CK-1: 2" and under, 125# steam @ 406ºF, 200# CWP @ 150ºF, screwed, bronze, horizontal swing. Crane #37, Hammond #IB904, Stockham #B319-Y, Walworth #3406, Milwaukee #509, Watts #G-5000, Nibco T-413B.

2. CK-14: 2-1/2" thru 12", 200# CWP, double disc wafer type, bronze or iron body, bronze trim, metal-to-metal or Viton seat, 316 SS shaft, Inconel 600 spring. Mission Duo Chek #12HPP (with Inconel springs), Mueller Steam Specialty Co. #71-AHB-K-W, Stockham #WG-961-EPDM or #WG-970-BUNA, Nibco w-920-W.

2.2 COMBINATION WATER AND FIRE PROTECTION SERVICE

A. Piping:

1. Pipe: Ductile iron pressure water pipe, ANSI/AWWA C151/A21.51, 200 psi pressure class, cement-mortar lined per ANSI/AWWA C104/A21.4.

2. Fittings: Ductile iron, ANSI/AWWA C110/A21.10, or ANSI/AWWA C153/A21.53, 200 psi pressure class, cement-mortar lined per ANSI/AWWA C104/A21.4, mechanical joints.

3. Joint: Mechanical joint with glands and gaskets and steel bolts. ANSI/AWWAC111/A21.11.

2.3 SANITARY DRAINAGE (ABOVE GROUND)
SANITARY INDIRECT DRAINAGE (ABOVE GROUND)
SANITARY VENT (ABOVE GROUND)
STORM DRAINAGE/CLEAR WATER WASTE (ABOVE GROUND)
CONDENSATE DRAINAGE (ABOVE GROUND)
GREASE SANITARY VENT (ABOVE GROUND – INSIDE BUILDING)

A. Design Pressure: Gravity
Maximum Design Temperature: 180ºF

B. Piping - 1-1/2" through 15":

1. Pipe and Fittings: Standard weight cast iron soil pipe, corrosion protective coating inside and outside, CISPI 301 or ASTM A888.

2. Joints: Heavy duty, neoprene sleeve gasket, ASTM C-564, 300 Series stainless steel shield, clamp, and screws with at least four screw type clamps, FM 1680 or ASTM C1540.

3. Adapters: Transitions from cast iron soil pipe to other pipe materials with manufactured adapters. Heavy duty neoprene sleeve gasket, ASTM C-564, 300 Series stainless steel shield, clamp, and screws with not less than four screw type clamps, FM 1680 or ASTM C1540.

C. Vent Flashing: Flash vents with premolded EPDM pipe flashing cones for single-ply membrane roofs.

D. Piping that is fully enclosed in walls (not open to the return air plenum system) is allowed to be meet requirements of below ground piping (PVC piping).

2.4 SANITARY DRAINAGE (BELOW GROUND - INSIDE BUILDING)
SANITARY VENT (BELOW GROUND - INSIDE BUILDING)
STORM DRAINAGE & CLEAR WATER WASTE (BELOW GROUND - INSIDE BUILDING)

A. Design Pressure: Gravity

B. Piping - 1-1/4” through 16” (Maximum Design Temperature: 140°F):

1. Pipe: Schedule 40 rigid, unplasticized PVC-DWV, or ABS-DWV, normal impact Type I, with plain ends, conforming to ASTM Standards D2665 or D2661. Cellular core piping is not acceptable.

2. Joints: Solvent-weld socket type with solvent recommended by pipe manufacturer.

3. Fittings: Unplasticized PVC-DWV, or ABS-DWV, normal impact Type I, with solvent-weld socket ends for Schedule 40 pipe.

4. Use: Use PVC or ABS only where allowed by local jurisdiction. Comply with all special requirements or limitations.

2.5 GREASE SANITARY DRAINAGE (BELOW GROUND – INSIDE BUILDING)
GREASE SANITARY DRAINAGE (ABOVE GROUND – INSIDE BUILDING)
GREASE SANITARY VENT (BELOW GROUND – INSIDE BUILDING)

A. Design Pressure: Gravity.

B. Piping - 1-1/4” through 16” (Maximum Design Temperature: 140°F):

1. Pipe: Schedule 40 rigid, unplasticized PVC-DWV, or ABS-DWV, normal impact Type I, with plain ends, conforming to ASTM Standards D2665 or D2661. Cellular core piping is not acceptable.

2. Joints: Solvent-weld socket type with solvent recommended by pipe manufacturer.

3. Fittings: Unplasticized PVC-DWV, or ABS-DWV, normal impact Type I, with solvent-weld socket ends for Schedule 40 pipe.

4. Use: Use PVC only where allowed by local jurisdiction. Comply with all special requirements or limitations.

2.6 UNIONS

A. Copper pipe - wrought copper fitting - ground joint.

2.7 AIR VENTS

A. Provide means for venting air at all high points in the piping system and at all other points where air may be trapped.

B. At end of main and other points where large volume of air may be trapped - Use 1/4" globe valve, angle type, 125 psi, Crane #89, attached to coupling in top of main, 1/4" discharge pipe turned down with cap.

2.8 RELIEF VALVES

A. RV-4: (Domestic Hot Water) Pressure and Temperature relief, cast bronze body and internal parts, stainless steel spring, test lever, threaded inlet and outlet. Maximum setting of 150 psi and 210ºF temperature. Capacities ASME certified and labeled. Acceptable Manufacturers: Cash Series FV, Watts #40, #120, #N240, #340.

2.9 BALANCING VALVE

A. Rated for 125 psi working pressure and 250ºF operating temperature, taps for determining flow with a portable meter, positive shutoff valves for each meter connection, memory feature, tight shutoff, and a permanent pressure drop between 1' and 2' water column at full flow with valve 100% open. Furnish with molded, removable insulation covers.

B. Provide a nomograph to determine flow from meter reading (and valve position on units which sense pressure across a valve). Graph shall extend below the specified minimum flow.

C. Flow rate of 0.5 GPM or larger: Valves in copper piping shall be brass or bronze. Acceptable Manufacturers: Flow Design “Accusetter”, Preso “B+”, Armstrong "CVB", Bell & Gossett "Circuit Setter Plus", Griswold “Quickset”, Gerand “Balvalve Venturi” or Nibco Globe Style balancing valve.

D. Flow rate less than 0.5 GPM: Valves in copper piping shall be brass or bronze. Cv value shall be less than 1.0 when valve is completely open, and minimum balanceable flow rate shall not exceed 0.1 GPM with a meter reading of at least 2.5 feet. Acceptable manufacturers: Bell & Gossett "Circuit Setter RF", Flow Design, Preso, Armstrong, Griswold, Gerand, or Nibco balancing valve.

E. Manufacturer shall size balancing valves for the scheduled flow rate. Flow rate shall be measurable on manufacturer's standard meters.

2.10 DRAIN VALVES

A. Drain valves shall be shutoff valves as specified for the intended service with added 3/4” male hose thread outlet and cap.

2.11 CONNECTIONS BETWEEN DISSIMILAR METALS

A. Connections between dissimilar metals shall be insulating dielectric types that provide a water gap between the connected metals, and that either allow no metal path for electron transfer or that provide a wide water gap lined with a non-conductive material to impede electron transfer through the water path.

B. Joints shall be rated for the temperature, pressure, and other characteristics of the service in which they are used, including testing procedure.

C. Aluminum, iron, steel, brass, copper, bronze, and stainless steel are commonly used and require isolation from each other with the following exceptions:

1. Iron, steel, and stainless steel connected to each other.

2. Brass, copper, and bronze connected to each other.

3. Brass or bronze valves and specialties connected in closed systems with steel, iron, or stainless steel on both sides of the brass or bronze valves and specialties. Where two or more brass or bronze items occur together, they shall be connected with brass nipples. Brass or bronze valves and specialties cannot be used as a dielectric separation between pipe materials.

D. Dielectric protection is required at connections to equipment of a material different than the piping.

E. Screwed Joints (acceptable up to 2" size):

1. Dielectric waterway rated for 300 psi CWP and 225°F.

2. Acceptable Manufacturers: Elster Group ClearFlow fittings, Victaulic Series 47, Grinnell Series 407, Matco-Norca.

F. Flanged Joints (any size):

1. Use 1/8" minimum thickness, non-conductive, full-face gaskets.

2. Employ one-piece molded sleeve-washer combinations to break the electrical path through the bolts.

3. Sleeve-washers are required on one side only, with sleeves minimum 1/32" thick and washers minimum 1/8" thick.

4. Install steel washers on both sides of flanges to prevent damage to the sleeve-washer.

5. Separate sleeves and washers may be used only if the sleeves are manufactured to exact lengths and installed carefully so the sleeves must extend partially past each steel washer when tightened.

6. Acceptable Manufacturers: EPCO, Central Plastics, Pipeline Seal and Insulator, F. H. Maloney, or Calpico.

2.12 LOCK OUT TRIM

A. Provide lock out trim for all quarter turn shutoff valves opening to atmosphere and installed in domestic water piping over 120°F, in compressed air piping, and as indicated on the drawings.

2.13 VALVE OPERATORS

A. Provide handwheels for gate valves and gear operators for butterfly valves.

2.14 VALVE CONNECTIONS

A. Provide all connections to match pipe joints. Valves shall be same size as pipe unless noted otherwise.

PART 3 - EXECUTION

3.1 PREPARATION

A. Install all products per manufacturer's recommendations.

B. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

C. Remove scale and dirt, on inside and outside, before assembly.

D. Connect to equipment with flanges or unions.

E. Use only piping materials rated for the maximum temperature of the application, e.g., do not use PVC for dishwasher drainage or piping that receives boiler blowdown.

3.2 TESTING PIPING

A. Sanitary Drainage:
Sanitary Vent:
Storm Drainage:

1. Test all piping with water to prove tight.

2. Test piping before insulation is applied.

3. Hydrostatically test all soil, waste, and vent piping inside of building with 10 feet head of water for 15 minutes. Inspect before fixtures are connected. If leaks appear, repair them and repeat the test.

4. Hydrostatically test interior downspouts with 10 feet head of water for 15 minutes with no leaks.

5. A smoke/air test at the same pressure may be used in lieu of the hydrostatic water test. Exception: Smoke/air test shall not be performed on plastic piping.

6. Test force mains with water at 105% of the operating pump discharge pressure for 15 minutes.

7. Test pressures stated above shall be as listed or as required by the Authority Having Jurisdiction, whichever is most stringent.

B. Hot Water - Potable and Non-Potable:
Cold Water - Potable and Non-Potable:
Service Water:

1. Test pipes underground or in chases and walls before piping is concealed.

2. Test all pipes before the insulation is applied. If insulation is applied before the pipe is tested and a leak develops which ruins the insulation, replace damaged insulation.

3. Test the pipe with 100 psig water pressure or equal inert gas such as nitrogen.

4. Hold test pressure for at least 2 hours.

5. Test to be witnessed by the Architect/Engineer's representative, if requested by the Architect/Engineer.

C. Fire Service:

1. Hydrostatically test the entire system for two hours at 200 psig. Maximum leakage shall be:

a. Interior Piping: 0 quarts per hour.

b. Underground Piping: 2 quarts per 100 joints per hour.

D. All Other Piping:

1. Test piping at 150% of normal operating pressure.

2. Piping shall hold this pressure for one hour with no drop in pressure.

3. Test piping using water, nitrogen, or air as compatible with the final service of the pipe. Do not use combustible fluids.

4. Drain and clean all piping after testing is complete.

3.3 CLEANING PIPING

A. Assembly:

1. Before assembling pipe systems, remove all loose dirt, scale, oil and other foreign matter on internal or external surfaces by means consistent with good piping practice subject to approval of the Architect/Engineer's representative. Blow chips and burrs from machinery or thread cutting operation out of pipe before assembly. Wipe cutting oil from internal and external surfaces.

2. During fabrication and assembly, remove slag and weld spatter from both internal and external joints by peening, chipping and wire brushing.

3. Notify the Architect/Engineer's representative before starting any post erection cleaning in sufficient time to allow witnessing the operation. Consult with and obtain approval from the Architect/Engineer's representative with regard to specific procedures and scheduling. Dispose of cleaning and flushing fluids properly.

4. Prior to blowing or flushing erected piping systems, disconnect all instrumentation and equipment, open wide all valves, and be certain all strainer screens are in place.

B. All Water Piping:

1. Flush all piping using faucets, flush valves, etc. until the flow is clean.

2. After flushing, thoroughly clean all inlet strainers, aerators, and other such devices.

3. If necessary, remove valves to clean out all foreign material.

C. Fire Service:

1. Flush all underground piping with minimum flow equal to the system design flow but not less than the following:

a. 390 gpm for 4" pipes.
b. 880 gpm for 6" pipes.
c. 1560 gpm for 8" pipes.
d. 2440 gpm for 10" pipes.
e. 3500 gpm for 12" pipes.

3.4 INSTALLATION

A. General Installation Requirements:

1. Provide dielectric connections between dissimilar metals.

2. Route piping in orderly manner and maintain gradient. Install to conserve building space.

3. Group piping whenever practical at common elevations.

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

5. Slope water piping and arrange to drain at low points.

6. Install bell and spigot piping with bells upstream.

7. Where pipe supports are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.

8. Seal pipes passing through exterior walls with a wall seal per Section 22 05 29. Provide Schedule 40 galvanized sleeve at least 2 pipe sizes larger than the pipe.

9. All non-potable outlets shall be clearly marked with a permanently affixed laminated sign with 3/8" high lettering saying "Non-Potable Water Not for Human Consumption." Sign shall have black lettering on a yellow background.

10. All vertical pipe drops to sinks or other equipment installed below the ceiling shall be routed within a wall cavity, unless specifically noted otherwise to be surface mounted.

B. Installation Requirements In Electrical Rooms:

1. Do not install piping or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the equipment.

C. Valves/Fittings and Accessories:

1. Install shutoff valves that permit the isolation of equipment/fixtures in each room without isolating any other room or portion of the building. Individual fixture angle stops do not meet this requirement. Exception: Back-to-back rooms in no more than two adjacent rooms.

2. Provide clearance for installation of insulation and access to valves and fittings.

3. Provide access doors for concealed valves and fittings.

4. Install valve stems upright or horizontal, not inverted.

5. Provide one plug valve wrench for every ten plug valves 2" and smaller, minimum of one. Provide each plug valve 2-1/2" and larger with a wrench with set screw.

6. Install balancing valves with straight, unobstructed pipe section both upstream and downstream as required, per manufacturer's installation instructions.

7. Install corrugated, stainless steel tubing system according to manufacturer's written instructions. Include striker plates to protect tubing from puncture where tubing is restrained and cannot move.

D. Underground Piping:

1. Install buried water piping outside the building with at least 5 feet of cover.

2. Underground fire protection service piping shall have at least 6-1/2 feet of cover, or as recommended by NFPA 24, whichever is greater.

3. Install thrust blocking and restraints on all underground fire protection service piping per NFPA 24 and as shown on drawings.

4. Install underground, sleeved, corrugated, stainless steel tubing system according to manufacturer's written instructions. Extend vent from sleeve to exterior of building and terminate with screened elbow.

5. Lay all underground piping in trenches. Provide and operate pumping equipment to keep trenches free of water.

6. For all underground piping, provide a foundation (the layer below the bedding) if the trench bottom is unstable. Lay underground plastic piping on 4" to 6" of sand bedding. When the trench is in rock, lay underground metallic piping on 6" of sand bedding. Provide recessed areas for pipe bells and joints. After joints are made, any misalignment in elevation shall be corrected by tamping sand around the pipe. Backfill with sand in uniform layers not over 6" deep to the spring line of all underground pipes, and carefully compact each layer to 90 percent Standard Proctor density. Backfill with sand up to 6" above pipe for landscaped areas. Remaining backfill may be soil. Under paving and buildings, the remaining backfill shall be sand and compacted to 98 percent Standard Proctor density.

E. Sanitary and Storm Piping:

1. Install all sanitary piping inside the building with a slope of at least the following:

Pipe Size	Minimum Slope
3" and under	- 0.25" per foot
4" and over	- 0.125" per foot

a. All sanitary systems transporting grease laden waste shall be sloped a minimum of 0.25" per foot regardless of size.

2. Install all storm piping inside the building with a slope of at least 0.125" per foot unless noted otherwise.

3. Install horizontal offset at all connections to roof drains to allow for pipe expansion.

4. Slope sanitary and storm piping outside the building to meet invert elevations shown on drawings and to maintain a minimum velocity of 3 feet per second.

5. All sanitary and storm piping shall have at least 42" of cover when leaving the building.

3.5 PIPE ERECTION AND LAYING

A. Carefully inspect all pipe, fittings, valves, equipment and accessories before installation. Any items that are unsuitable, cracked or otherwise defective shall be removed from the job immediately.

B. All pipe, fittings, valves, equipment and accessories shall have factory applied markings, stampings, or nameplates with sufficient data to determine their conformance with specified requirements.

C. Exercise care at every stage of storage, handling, laying and erecting to prevent entry of foreign matter into piping, fittings, valves, equipment and accessories. Do not install any item that is not clean.

D. Until system is fully operational, all openings in piping and equipment shall be kept closed except when actual work is being performed on that item or system. Closures shall be plugs, caps, blind flanges or other items specifically designed and intended for this purpose.

E. Run pipes straight and true, parallel to building lines with minimum use of offsets and couplings. Provide only offsets required to provide needed headroom or clearance and to provide needed flexibility in pipe lines.

F. Make changes in direction of pipes only with fittings or pipe bends. Changes in size only with fittings. Do not use miter fittings, face or flush bushings, or street elbows. All fittings shall be of the long radius type, unless otherwise shown on the drawings or specified.

G. Provide flanges or unions at all final connections to equipment, traps and valves.

H. Arrange piping and connections so equipment served may be totally removed without disturbing piping beyond final connections and associated shutoff valves.

I. Use full and double lengths of pipe wherever possible.

J. Unless otherwise indicated, install all piping, including shutoff valves and strainers, to coils, pumps and other equipment at line size with reduction in size being made only at control valve or equipment.

K. Cut all pipe to exact measurement and install without springing or forcing except in the case of expansion loops where cold springing is indicated on the drawings.

L. Underground pipe shall be laid in dry trenches maintained free of accumulated water. Provide and operate sufficient pumping equipment to maintain excavations, trenches and pits free of water. Dispose of pumped water so operation areas and other facilities are not flooded. Pipe laying shall follow excavating as closely as possible.

M. Unless otherwise indicated, branch take-offs shall be from top of mains or headers at either a 45º or 90º angle from the horizontal plane for air lines, and from top, bottom or side for liquids.

3.6 DRAINING AND VENTING

A. Unless otherwise indicated on the drawings, all horizontal water and compressed air lines, including branches, shall pitch 1" in 40 feet to low points for complete drainage, removal of condensate and venting.

B. Maintain accurate grade where pipes pitch or slope for venting and drainage. No pipes shall have pockets due to changes in elevation.

C. Provide drain valves at all low points of water piping systems for complete or sectionalized draining.

D. Provide drip legs at low points and at the base of all risers in compressed air pipes. Drip legs shall be full line size on pipes through 4" and at least 4", but not less than half line size over 4". Drip legs shall be 12" minimum length, capped with a reducer to a drain valve.

E. Use eccentric reducing fittings on horizontal runs when changing size of pipes for proper drainage and venting. Install compressed air and gravity drain pipes with bottom of pipe and eccentric reducers in a continuous line; all other liquid lines with top of pipe and eccentric reducers in a continuous line.

F. Provide air vents at high points and wherever else required to eliminate air in all water piping systems.

G. Install air vents in accessible locations. If necessary to trap and vent air in a remote location, install an 1/8" pipe from the tapping location to an accessible location and terminate with a venting device.

H. All vent and drain piping shall be of same materials and construction for the service involved.

3.7 PLUMBING VENTS

A. Vent as shown on the drawings and in accordance with all codes having jurisdiction.

B. Extend the high side of the soil and waste stacks at least 12" above roof.

C. Flash pipes at roof with premolded EPDM pipe flashing cones adhered to roof membrane by General Contractor. Secure top of cone with stainless steel clamp and seal watertight.

D. Increase vent pipes through the roof two pipe sizes with long increasers located at least 12" below the roof.

E. In no case shall the vent through the roof be less than 4" in diameter.

F. Vent pipes through the roof shall be located a minimum of 15 feet from any air intake or exhaust opening on the roof.

3.8 BRANCH CONNECTIONS

A. For domestic water and vent systems only, make branch connections with standard tee or cross fittings of the type required for the service.

B. Reducers are generally not shown. Where pipe sizes change at tee, the tee shall be the size of the largest pipe shown connecting to it.

C. Do not use double wye or double combination wye and eighth bend DWV fittings in horizontal piping.

D. Branch connections from the headers and mains may be mechanically formed using an extraction device. The branch piping connection shall be brazed connection for the following services only:

1. Domestic water piping above grade.

E. Branch connections from headers and mains may be cut into black steel pipe using forged weld-on fittings.

F. Forged weld-on fittings are limited as follows:

1. Must have at least same pressure rating as the main.
2. Main must be 2-1/2" or larger.
3. Branch line is at least two pipe sizes under main size.

3.9 JOINING OF PIPE

A. Solder Joints:

1. Make up joints with 100% lead-free solder, ASTM B32. Cut tubing so ends are perfectly square and remove all burrs inside and outside. Thoroughly clean sockets of fittings and ends of tubing to remove all oxide, dirt and grease just prior to soldering. Apply flux evenly, but sparingly, over all surfaces to be joined. Heat joints uniformly so solder will flow to all mated surfaces. Wipe excess solder, leaving a uniform fillet around cup of fitting.

2. Flux shall be non-acid type.

3. Solder end valves may be installed directly in the piping system if the entire valve is suitable for use with 470ºF melting point solder. Remove discs and seals during soldering if they are not suitable for 470ºF.

B. Solvent Weld Joints (PVC):

1. Make joints with a two-step process. Use primer conforming to ASTM F656 and solvent cement conforming to ASTM D2564.

C. Sleeve Gaskets (No-Hub) (Sanitary and Storm Pipe):

1. Gasket shall be heavy weight class, conforming to ASTM C564.

2. The gasket shall have an internal center stop.

3. The gasket shall be covered by a stainless steel band secured with a minimum of four stainless steel bands per fitting/joint.

4. Sleeve gaskets shall be installed in accordance with the manufacturer's installation instructions.

3.10 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

A. Provide necessary connections at the start of individual sections of mains for adding chlorine.

B. Before starting work, verify system is complete, flushed and clean.

C. 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).

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

E. Bleed water from all outlets to ensure chlorine distribution throughout the entire domestic water system.

F. Verify initial chlorination levels by testing at minimum 15% of outlets located throughout entire building, including the last fixture connected to each main and each branch extending over 50 feet from a main.

G. Maintain disinfectant in system for 24 hours, after which test at minimum 15% of outlets located throughout entire building, including the last fixture connected to each main and each branch extending over 50 feet from a main. If final disinfectant residual tests less than 25 mg/L at any one of the tested outlets, flush the entire system and repeat disinfection and testing procedure.

H. After final disinfectant residuals test at or above 25 mg/L after a minimum 24-hour duration, flush disinfectant from system at a minimum velocity of 3.0 feet/second until residual is equal to that of incoming water or 1.0 mg/L.

I. Take water samples, no sooner than 24 hours after flushing, from 2% of outlets and from water entry. Obtain, analyze, and test samples in accordance with AWWA C651, Section 5 - Verification.

3.11 SERVICE CONNECTIONS

A. Provide new sanitary and/or storm sewer services. Before commencing work check invert elevations needed for sewer connections, confirm inverts and verify these can be properly connected with slope for drainage and cover to avoid freezing.

B. Provide new water service with water meter with bypass valves. Provide sleeve in wall for service main per Section 22 05 29.

END OF SECTION

SECTION 22 10 23
NATURAL GAS AND PROPANE PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Pipe and Pipe Fittings.
B. Valves.
C. Natural Gas Piping System.
D. Propane Piping System.

1.2 QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body. Remanufactured valves are not acceptable.

B. Welding Materials, Procedures, and Operators: Conform to ASME Section 9, ANSI/AWS D1.1, and applicable state labor regulations.

C. Welders Certification: In accordance with ANSI/ASME Sec 9 or ANSI/AWS D1.1.

1.3 SUBMITTALS

A. Submit product data under provisions of Section 22 05 00. Include data on pipe materials, fittings, valves, and accessories.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store and protect piping to prevent entrance of foreign matter into pipe and to prevent exterior corrosion.

B. Deliver and store valves in shipping containers with labeling in place.

1.5 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 22 05 00 for the required natural gas piping system electronic CAD drawings to be provided to Coordinating Contractor for inclusion into composite coordination drawings.

PART 2 - PRODUCTS

2.1 NATURAL GAS (0 TO 125 PSI)
PROPANE (0 TO 125 PSI)

A. Design Pressure: 125 psi.
Maximum Design Temperature: 350ºF

B. Piping - 2" and Under:

1. Pipe: Standard weight steel, threaded and coupled, ASTM A53.

2. Joints: Screwed. (NOTE: For below ground, all sizes to have welded joints.)

3. Fittings: 150# steam - 300# CWP, black malleable iron, banded, ASTM A197, ANSI B16.3.

4. Unions: 250# - 500# CWP, black malleable iron, ANSI B16.39, ground joint with brass seat.

C. Piping – 2" and Under:

1. Pipe: Corrugated stainless steel tubing, ASTM A240 Series 300 stainless steel, ANSI AGA-LC1.

2. Jacket: UV resistant, electrically conductive polyethylene, color: black, ASTM E84 25-50 flame and smoke.

3. Fittings: Brass with mechanical ends to fit tubing. ASME B1.20.1 threaded ends for connections to threaded pipes and components.

4. Striker Plates: Minimum 16 gaugehardened steel, corrosion resistant, primed and zinc coated. Install to protect tubing from penetrations.

5. Limits: 5 psi or less. For use only at termination to fixed outlets or equipment, maximum length: 48". Provide malleable iron, flange mounted, straight or 90 fitting at wall termination with maximum 12" length of tubing on inlet of flange.

6. Manufacturer: TracPipe, Gastite, Parker PGP2.

D. Piping – 2" and Under:

1. Pipe: Corrugated stainless steel tubing, ASTM A240 Series 300 stainless steel, ANSI AGA-LC1.

2. Jacket: UV resistant, electrically conductive polyethylene, color: black, ASTM E84 25-50 flame and smoke.

3. Sleeve: Polyethylene, pre-sleeved from factory with field installed vent tees and water/gas tight heat shrink cuffs on each end.

4. Fittings: Brass with mechanical ends to fit tubing. ASME B1.20.1 threaded ends for connection to threaded pipes and components.

5. Limits: 5 psi or less. Below ground – inside building.

6. Manufacturer: TracPipe.

E. Piping - 2-1/2" and Over:

1. Pipe: Standard weight black steel, beveled ends, ASTM A53.

2. Joints: Butt welded and flanged.

3. Fittings: Standard weight seamless steel, butt weld type, ASTM A234, Grade I, ANSI B16.9.

4. Flanges: 150# forged steel, weld neck or slip-on, ASTM A181, Grade I, ANSI B16.5.

F. Shutoff Valves/Throttling Valves:

1. BA-13: 2" and under, threaded 600 psi CWP; UL listed for 250# LP, flammable liquid, heating oil, natural and manufactured gases, 150 psi steam, bronze body and chrome plated brass ball, Teflon seats and packing. Apollo #80-100, Nibco #T580-70-UL or #T585-70-UL, Watts #B-6000.

2. PL-1: 2" and under, 125# steam @ 450ºF, 175# CWP @ 180ºF, cast iron body, screwed, full port. Walworth #1700, DeZurik #425, S-RS49.

3. PL-2: 2-1/2" thru 4", 125# steam @ 450ºF, 175# CWP @ 180ºF, flanged, cast iron body, full port. Walworth #1700F, DeZurik #425, F-RS49.

2.2 DRAIN VALVES AND BLOWDOWN VALVES

A. Drain valve and blowdown valve shall mean a shutoff valve as specified for the intended service with added 3/4" male hose thread outlet, cap, and retaining chain.

PART 3 - EXECUTION

3.1 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. Connect to all equipment with flanges or unions.

D. After completion, fill, clean, and treat systems. Refer to Section 23 25 00 for treatment.

3.2 TESTING PIPING

A. Low Pressure - Up to 1 psi:

1. Test piping with 20 psi air pressure. System must hold this pressure without adding air for two hours.

B. High Pressure - Above 1 psi:

1. Test piping with compressed air at twice the operating gas pressure, but at least 20 psi. System must hold this pressure without adding air for two hours.

C. A non-combustible odorant, such as oil of wintergreen, may be added to help locate leaks.

3.3 CLEANING PIPING

A. Assembly:

1. Prior to assembly of pipe and piping components, remove all loose dirt, scale, oil and other foreign matter on internal or external surfaces by means consistent with good piping practice subject to approval of the Architect/Engineer. Blow chips and burrs out of pipe before assembly. Wipe cutting oil from internal and external surfaces.

2. During fabrication and assembly, remove slag and weld spatter from both internal and external joints by peening, chipping and wire brushing to the degree consistent with good piping practices.

3. Notify the Architect/Engineer prior to starting any post erection cleaning operation in time to allow witnessing the operation. Properly dispose of cleaning and flushing fluids.

4. Prior to blowing or flushing erected piping systems, disconnect all instrumentation and equipment, open wide all valves, control valves, and balance valves, and verify all strainer screens are in place.

3.4 INSTALLATION

A. Route piping in orderly manner, straight, plumb, with consistent pitch, parallel to building structure, with minimum use of offsets and couplings. Provide only offsets required for needed headroom or clearance and needed flexibility in pipe system.

B. Install piping to conserve building space, and not interfere with other work.

C. Do not install piping or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the equipment.

D. Group piping whenever practical at common elevations.

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

F. Provide valve position indicator on all valves 10'-0" or greater above finish floor and not located above ceiling.

G. Provide clearance for access to valves and fittings.

H. Provide access doors where valves are not exposed.

I. Prepare pipe, fittings, supports, and accessories for finish painting.

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

K. Provide shutoff valves and flanges or unions at all connections to equipment, traps, and items that require servicing.

L. Arrange piping and piping connections so equipment may be serviced or totally removed without disturbing piping beyond final connections and associated shutoff valves.

M. Reducers are generally not shown. Where pipe sizes change at tee, the tee shall be the size of the largest pipe shown connecting to it. Where pipe sizes are not shown, the larger size in either direction shall continue through the fitting nearest to the indication of a smaller pipe size.

N. Lay all underground piping in trenches. Provide and operate pumping equipment to keep trenches free of water.

O. Provide flanges or unions at all final connections to equipment, traps and valves.

P. Seal pipes passing through exterior walls with a wall seal per Section 23 05 29. Provide Schedule 40 galvanized sleeve at least 2 pipe sizes larger than the pipe.

Q. For all underground piping, provide a foundation (the layer below the bedding) if the trench bottom is unstable. Lay underground plastic piping on 4" to 6" of sand bedding. When the trench is in rock, lay underground metallic piping on 6" of sand bedding. Provide recessed areas for pipe bells and joints. After joints are made, any misalignment in elevation shall be corrected by tamping sand around the pipe. Backfill with sand in uniform layers not over 6" deep to the spring line of all underground pipes, and carefully compact each layer to 90 percent Standard Proctor density. Backfill with sand up to 6" above pipe for landscaped areas. Remaining backfill may be soil. Under paving and buildings, the remaining backfill shall be sand and compacted to 98 percent Standard Proctor density.

R. All vertical pipe drops to equipment installed below the ceiling shall be routed within a wall cavity, unless specifically noted otherwise to be surface mounted.

S. Install underground plastic pipe with an electrically continuous corrosion-resistant tracer wire (minimum AWG 14) or tape per section 22 05 53 to facilitate locating. One end of the tracer wire or tape shall be brought aboveground at a building wall or riser.

T. Install corrugated, stainless steel tubing system according to manufacturer's written instructions. Include striker plates to protect tubing from puncture where tubing is restrained and cannot move.

U. Install underground, sleeved, corrugated, stainless steel tubing system according to manufacturer's written instructions. Extend vent from sleeve to exterior of building and terminate with screened elbow.

V. Each above ground portion of a corrugated stainless steel tubing gas piping systems shall be bonded to the electrical service grounding electrode system. The bonding jumper shall connect to a metallic pipe or fitting between the point of delivery and the first downstream corrugated stainless steel tube fitting. The bonding jumper shall not be smaller than 6 AWG copper wire or equivalent. Gas piping systems that contain one or more segments of corrugated stainless steel tubing shall be bonded in accordance with this section.

W. Each above ground portion of a gas piping system, other than corrugated stainless steel tubing systems, that is likely to become energized shall be electrically continuous and bonded to an effective ground-fault current path. Gas piping, other than corrugated stainless steel tubing, shall be considered to be bonded when it is connected to appliances that are connected to the appliance grounding conductor of the circuit supplying that appliance.

X. Gas piping shall not be used as a grounding conductor or electrode.

Y. Where a lightning protection system is installed, the bonding of the gas piping shall be in accordance with NFPA 780, Standard for the Installation of Lightning Protection Systems.

3.5 PIPE ERECTION AND LAYING

A. Carefully inspect all pipe, fittings, valves, equipment and accessories prior to installation. Immediately reject and remove from the job any items which are unsuitable, cracked or otherwise defective.

B. All pipe, fittings, valves, equipment and accessories shall have factory-applied markings, stampings, or nameplates sufficient to determine their conformance with specified requirements.

C. Exercise care at every stage of storage, handling, laying and erecting to prevent entry of foreign matter into piping, fittings, valves, equipment and accessories. Do not erect or install any unclean item.

D. During construction, until system is fully operational, keep all openings in piping and equipment closed at all times except when actual work is being performed on that item. Closures shall be plugs, caps, blind flanges or other items designed for this purpose.

E. Change direction of pipes only with fittings or pipe bends. Change size only with fittings. Do not use miter fittings, face or flush bushings, or street elbows. **All fittings shall be long radius type**, unless otherwise shown on the drawings or specified. Construct welded elbows of angles not available as standard fittings by cutting and welding standard elbows to form smooth, long radius fittings.

F. Use full and double lengths of pipe wherever possible.

G. Cut all pipe to exact measurement and install without springing or forcing.

H. Do not create, even temporarily, undue loads, forces or strains on valves, equipment or building elements.

I. Underground pipe shall be laid in dry trenches maintained free of accumulated water. Provide and operate sufficient pumping equipment to maintain excavations, trenches and pits free of water. Dispose of pumped water so operation areas and other facilities are not flooded. Pipe laying shall follow excavating as closely as possible.

3.6 DRAINING AND VENTING

A. Unless otherwise indicated on the drawings, all horizontal pipes, including branches, shall pitch 1" in 40 feet to low points for complete drainage.

B. Use eccentric reducing fittings on horizontal runs when changing size for proper drainage and venting. Install gas pipes with bottom of pipe and eccentric reducers in a continuous line.

C. Provide drip legs at low points and at the base of all risers in gas pipes. Drip legs shall be full line size on pipes through 4" and at least 4", but not less than half line size over 4". Drip legs shall be 12" minimum length, capped with a reducer to a drain valve.

3.7 BRANCH CONNECTIONS

A. Make branch connections with standard tee or cross fittings of the type required for the service unless otherwise specified herein or detailed on the drawings.

B. At the option of the Contractor, branch connections from headers and mains may be cut into black steel pipe using forged weld-on fittings.

C. Use of forged weld-on fittings is also limited as follows:

1. Must have at least same pressure rating as the main.
2. Header or main must be 2-1/2" or over.
3. Branch line is at least two pipe sizes under header or main size.

D. Reducers are generally not shown. Where pipe sizes change at tee, the tee shall be the size of the largest pipe shown connecting to it.

E. All branch piping connections for natural gas shall take off on the top or on the side of the main.

3.8 JOINING OF PIPE

A. Threaded Joints:

1. Ream pipe ends and remove all burrs and chips.
2. Protect plated pipe and valve bodies from wrench marks when making up joints.
3. Apply Teflon tape to male threads.

B. Flanged Joints:

1. Steel flanges shall be raised face.

2. Bolting for services up to 500ºF shall be ASTM A307 Grade B with square head bolts and heavy hexagonal nuts conforming to ANSI B18.2.1 "Square and Hex Bolts" and B18.2.2 "Square and Hex Nuts".

3. Torque bolts in at least three passes, tightening to 1/3, 2/3, and final torque in a cross pattern with an indicating torque wrench for equal tension in all bolts.

4. Gaskets for flat face flanges shall be full face type. Gaskets for raised faced flanges shall conform to requirements for "Group I Gaskets" in ANSI B16.5. Unless otherwise specified gaskets shall meet the following requirements:

   a. Gasket material and thickness approved by manufacturer for intended service, chemical compatibility, pipe system test pressure, and operating temperature range.

   b. Maximum pressure rating of at least 250 psig.

   c. Minimum temperature rating: -10°F.

   d. Maximum temperature rating of at least 170°F for water systems operating 140°F and less.

C. Welded Joints:

1. Welding of all pipe joints, both as to procedures and qualification of welders, shall be in accordance with Section IX, ASME "Boiler & Pressure Vessel Code" unless local codes take precedence.

2. Furnish certificates qualifying each welder to the Owner's Representative prior to start of work.

3. The Owner's Representative reserves the right to require qualifying demonstration, at the Contractor's expense, of any welders assigned to the job.

4. Ends of pipe and fittings to be joined by butt-welding shall be beveled, cleaned to bare metal and internal diameters aligned before tack welding.

5. Backing rings shall be used for all butt weld joints 3" size and over, and for all sizes where operating pressure is over 200 psig and/or temperature is over 400ºF. Backing rings shall be of the material being welded.

3.9 PAINTING EXPOSED PIPE

A. Paint all outdoor exposed natural gas piping the color selected by Owner or Architect/Engineer.

3.10 SERVICE CONNECTIONS

A. Provide new gas service complete with gas meter and regulators. Verify gas service pressure with the Utility Company. Gas meter shall have pulse output to allow monitoring by building management system.

END OF SECTION

SECTION 22 10 30
PLUMBING SPECIALTIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Floor Drains.
B. Cleanouts.
C. Traps.
D. Backflow Preventers.
E. Water Hammer Arresters and Air Chambers.

1.2 QUALITY ASSURANCE

A. Manufacturer: For each product specified, provide components by same manufacturer throughout.

1.3 SUBMITTALS

A. Submit shop drawings under provisions of Section 22 05 00.

B. Include sizes, rough-in requirements, service sizes, and finishes.

PART 2 - PRODUCTS

2.1 CLEANOUTS

A. Provide cleanouts as shown and specified on the drawings as well as required by code.

B. Coordinate floor cleanout cover with surrounding floor finish. Provide either solid, recessed for tile or terrazzo or carpet marker as applicable.

C. Cleanouts on exposed pipes shall be cast iron with heavy duty cast brass plug with raised head.

D. Cleanout shall be same size as the pipe up to 6" and 6" for larger pipes.

2.2 YARD CLEANOUTS

A. Provide yard cleanouts as shown and specified on the drawings as well as required by code.

B. Cleanout shall be same size as pipe up to 6" and 6" for larger pipes.

2.3 TRAPS

A. Provide all individual connections to the sanitary system with P-traps, except where such drains discharge directly into a properly trapped collection basin or sump. Unless otherwise specified or shown, traps shall be:

1. Chromium plated cast brass when used with plumbing fixtures or when installed exposed in finished spaces.

2. Insulated at accessible lavatories.

3. Cast iron, deep-seal pattern where concealed above ceiling, below grade or in unfinished areas.

4. Deep-seal pattern of the same material and/or coating where drainage lines are of special materials or coatings such as polypropylene, PVDF, CPVC, etc.

B. All traps shall have accessible, removable cleanouts, except where installed on floor drains with removable strainers.

C. Each trap shall be completely filled with water at the end of construction but before building turnover to the Owner. All floor drains, floor sinks, trench drains, etc. shall be filled with water and a 1/2" minimum layer of mineral oil.

2.4 FLOOR DRAINS AND SINKS

A. Provide floor drains and sinks as shown and specified on the drawings as well as required by code.

2.5 BACKFLOW PREVENTERS

A. Provide backflow preventers as shown and specified on the drawings as well as required by code.

2.6 WATER HAMMER ARRESTERS AND AIR CHAMBERS

A. Provide water hammer arresters as shown and specified on the drawings as well as required by code.

B. ANSI A112.26.1; sized and located in accordance with PDI WH-201, precharged for operation between -100ºF and 300ºF and maximum 250 psig working pressure.

C. Air chambers shall meet the requirements of the applicable plumbing code. Minimum 12" long at fixtures and minimum 24" long on risers. Air chambers shall be the same size or larger than the piping it is connected to.

PART 3 - EXECUTION

3.1 INSTALLATION AND APPLICATION

A. Coordinate construction to receive drains at required invert elevations.

B. Install all items per manufacturer's instructions.

C. Water Hammer Arresters and Air Chambers:

1. Install water hammer arresters in accessible locations. Provide access doors as required. Coordinate type with Architect/Engineer/Owner.

2. Water hammer arrestors shall be installed in cold and hot water lines upstream of all plumbing fixtures or equipment, with a quick acting valve or multiple quick acting valves. Quick acting valves shall be defined as solenoid actuated valves, manual flush valves, sensor activated faucets and flush valves, squeeze handle spray faucets, and other similar type valves.

3. Install multiple water hammer arrestors in toilet group branch piping greater than 20 feet in developed length from the cold and hot water mains.

4. Install air chambers at each fixture not protected by a water hammer arrester.

D. Cleanouts:

1. Provide cleanouts where shown on the drawings and as required by code, but in no case farther apart than 50 feet in pipe less than 6" size and 75 feet apart in 6" and larger pipes inside the building.

2. Provide cleanouts at bases of all sanitary and storm risers as shown on the drawings and as required by code.

3. Extend cleanouts to the floor with long sweep elbows.

4. Install a full size, two-way cleanout within 5 feet of the foundation inside or outside of building.

5. Extend cleanouts to finished floor or wall surface. Lubricate threaded cleanout plugs with graphite and linseed oil. Ensure clearance at cleanouts for rodding of drainage system.

6. Wall cleanouts shall be installed above the flow line of the pipe they serve, but no less than 12" above the finished floor.

E. Yard Cleanouts:

1. Install cleanouts on maximum 90 foot centers (including riser) for pipes 8" and smaller.

2. Extend cleanout to grade. Encase cleanout in 5" thick concrete pad extending 6" beyond cleanout, set low enough not to interfere with lawn mowers.

F. Floor Drains:

1. Drains in upper floors shall have a flashing of EPDM or similar membrane sheet. The sheet shall be at least 36" X 36" square with the drain in the center. Clamp membrane in auxiliary clamping ring of floor drain.

2. Use alternate sealing method when installing drains in existing floor slabs.

3. Coordinate sloping requirements with the architectural plans and specifications.

G. Backflow Preventer:

1. Provide an air gap fitting and piping to drain. On 2-1/2" and larger units, install a tail piece from air gap fitting to drain to prevent water from spraying out of drain air gap receptor. Maintain air gap distance required by Code.

2. Units shall be field tested and tagged in accordance with manufacturer's instructions and applicable codes by a certified tester before initial operation.

3. Install unit between 12" and 60" above finish floor.

END OF SECTION

SECTION 22 30 00
PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Water Heaters.
B. Water Softeners.

1.2 QUALITY ASSURANCE

A. Products and installation of specified products shall conform to recommendations and requirements of the following organizations:

1. American Gas Association (AGA).
2. National Sanitation Foundation (NSF).
3. American Society of Mechanical Engineers (ASME).
4. National Board of Boiler and Pressure Vessel Inspectors (NBBPVI).
5. National Electrical Manufacturers' Association (NEMA).
6. Underwriters' Laboratories (UL).

1.3 SUBMITTALS

A. Submit shop drawings under provisions of Section 22 05 00.

B. Include dimension drawings of water heaters indicating components and connections to other equipment and piping.

C. Include heat exchanger dimensions, size of tappings, and performance data.

D. Include dimensions of tanks, tank lining methods, anchors, attachments, lifting points, tappings, and drains.

E. For equipment connected to an electric power source, submit short circuit rating (SCCR) of integrated unit.

F. Submit manufacturer's installation instructions including control and wiring diagrams.

G. Submit manufacturer's certificate that pressure vessels meet or exceed specified requirements.

H. Submit operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.

I. Submit a current water analysis from the actual water source serving the project site for softening equipment verification before sending shop drawings to the Architect/Engineer.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Provide temporary inlet and outlet caps. Maintain caps in place until installation.

1.5 REGULATORY REQUIREMENTS

A. Water heaters shall conform to AGA, ANSI/NFPA 54, ANSI/NFPA 70, ANSI/UL 1453 as applicable.

B. Conform to ANSI/ASME Section 8 Division 1 for fabrication of steel pressure vessels.

C. Conform to ANSI/ASME Section 10 for manufacture of fiber-reinforced plastic pressure vessels.

PART 2 - PRODUCTS

2.1 WATER HEATERS

A. All water heaters shall be as scheduled on the drawings and per 23 33 39 specification.

2.2 COMMERCIAL WATER SOFTENER

A. Automatic duplex water softener to remove hardness to no more than 1.0 grains per gallon as determined by an ASTM Standard Soap Test Method.

B. Incoming water contains approximately 21 grains per gallon based on information obtained from the local utility. Obtain a current water sample from the water source serving that will be serving the project and have it analyzed to make sure equipment can perform as designed. Provide report to the Architect/Engineer before providing shop drawings.

C. Softener Tanks: Fiberglass reinforced polyester, designed for a minimum working pressure of 100 psig, hydrostatically tested at 150% of working pressure. Sideshell height to allow a minimum freeboard space of 50% of the mineral bed depth for adequate expansion during backwashing. Softener tank not over 13 inches diameter, 54 inches sideshell height. Tank bottom will be supported with a molded structural base. The top opening will be 1.5 inches with a threaded connection.

D. Distribution System: Soft water collector and backwash distributor, hub and arm radial or healer lateral type lower distribution system. Distribution shall be covered with a single layer of washed inorganic media to evenly distribute the service and backwash water and support the mineral bed tank.

E. Brine Tank: Rigid polyethylene or fiberglass with tight fitting cover, size not over 18 inches diameter, 40 inches height, corrosion-free elevated salt platform, float-operated plastic fitted brine valve to control brine withdrawal and freshwater refill. The brine valve shall provide positive shutoff to prevent air from entering the system. Brine eductor shall dilute brine flow to softener. Brine shall be provided with a float-operated shutoff valve to keep the tank from overfilling.

1. Provide initial fill of brine tank with manufacturer recommended salt product. Tank shall be full at time the Owner is given occupancy.

F. Softener Ion Exchange Resin: Virgin, high capacity, standard mesh of sulfonated polystyrene type stable over the entire PH range, with good resistance to bead fracture from attrition or osmotic shock. Solid resin, of the proper particle size of 20 to 50 mesh, U.S. standard screen, and will contain no agglomerates, shells, plates, or other shapes to interfere with normal function of water softener. The system shall include 2 cubic feet of exchange resin per vessel and a total of 4 cubic feet of resin for the system.

G. System Efficiency: System shall have minimum efficiency of 4000 grains of hardness removed per pound of salt usage. Include brine reclaim if required to meet the efficiency requirements if normal system does not have this minimum efficiency requirement.

H. Pipes, Valves and Fittings: Pipe shall be galvanized, standard weight steel, Type L copper, or Schedule 5 stainless steel. Fittings shall be 125 lb. Class malleable iron for steel, Type L for copper, and Schedule 5 for stainless steel. All piping shipped assembled shall be hydrostatically tested for leaks at the factory.

I. Water Testing Equipment: Complete with sample cock installed to obtain samples of effluent water. Furnish a complete test kit for conducting soap tests.

J. Automatic Controls:

1. System design shall use Demand Recall controls.

2. The main control shall be a fully automatic, top-mounted brass control and sized with 1.5 inch NPT inlet and outlet connections. The top-mounted main control design will be motor driven, mechanically activated, with five pistons to accomplish the regeneration steps of backwash, brine draw/rinse, fast rinse, and brine refill, in addition to the service position.

3. The main control shall incorporate self-adjusting flow regulators to control the rate of flow and prevent resin loss during backwash, regardless of the system pressure fluctuations between 30 and 120 psig.

4. Valves shall be controlled by integral electronic controls. Controls shall display status of each unit with respect to service and regeneration. Controls for multi-tank systems shall be capable of operating units simultaneously, alternating unit service, or progressively bringing additional units on and off line as needed to maintain flow rates and reduce risk of channeling.

5. Regeneration shall be initiated by volume programmed so units are unable to regenerate simultaneously.

6. The unit shall be supplied so that the valve will allow automatic bypass of untreated water during regeneration. The bypass shall be integral to the main control.

7. All control mechanisms shall be enclosed in a UL listed NEMA 3 enclosure. A fully integrated, programmable, microprocessor-driven electronic controller shall be provided to automatically cycle the main control through the regeneration sequence.

8. Each controller shall be provided with dry contacts that will be able to send alarms to the building automation system.

9. Electrical Requirements: Each valve shall be prewired with a plug and cord and an inline breaker to plug into a standard receptacle or wired to a common control panel so a single electrical connection can be provided. 120 volt-single phase. Electric power shall not be needed for manual regeneration. Inlet hydraulic pressure shall be required.

K. Extra Stock:

1. Furnish extra materials as listed below that match products installed and that are packaged and labeled for storage.

   a. Provide 200 lbs. additional salt in the same form as the original load. Salt shall be delivered and stored on pallet(s). Locate the pallet(s) per the Owner's direction.

   b. Provide one additional gasket for each handhole and manway.

L. Warranty:

1. Provide a standard one-year warranty on the entire unit from the date of final acceptance.

2. Provide a standard two-year warranty on the control valve internal parts, the brine valve and associated parts, and the salt storage container internal components.

3. Provide a standard five-year warranty on the control valve body, fiberglass wound container(s) (if applicable), salt storage container(s) (if applicable), and epoxy lined steel conditioner tank(s) (if applicable).

M. Acceptable Manufacturers: Hellenbrand, Capitol Water Softener, Sterling, Avid.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all items in accordance with manufacturer's instructions.

3.2 WATER HEATER INSTALLATION

A. Install water heaters on concrete bases. Coordinate sizes and locations of concrete bases. Refer to Section 22 05 29.

B. Install water heaters level and plumb, according to drawings, manufacturer's instructions, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

C. Install combination temperature and pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend drain piping full size from relief valve and discharge by positive air gap onto closest floor drain. Discharge pipe material shall be same as domestic water piping.

D. Install gas water heaters according to NFPA 54.

3.3 WATER SOFTENER INSTALLATION

A. Verify connection sizes and piping type with cold water and soft cold water piping. Provide dielectric connection between dissimilar metals. Pressure gauges are required at hard water inlet and soft water outlet of each softener.

B. Provide system start-up and subsequent service, with stocking of spare parts by authorized dealer or factory trained personnel.

C. Provide complete instructions covering installation and operation of the softening system in booklet form. All components shall be easily identified, in exploded views, by individual part number.

D. Provide six hours of instruction and orientation to the Owner's maintenance staff by factory trained personnel. System walk-through, including programming of any system controllers shall be included in training.

END OF SECTION

SECTION 22 33 39
SOLAR WATER HEATING SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Solar System Piping and Insulation
B. Solar Collector Subsystem
C. Solar Collector Array
D. Solar Equipment
E. Control and Instrumentation Subsystem

1.2 QUALITY ASSURANCE

A. Installer shall be NABCEP certified. Exceptions can be made if installer is member of NABCEP Exam Committee, which prohibits him/her from participating in the exam, and if he/she can show experience of being the lead worker on five (5) solar thermal projects, where at least two (2) of them must have been commercial projects. Exceptions also can be made for participants of the most recent NABCEP certification test if the installer passed the test but certification is not yet issued. The qualified and certified installer has to be the supervisor and at the job site during installation.

1.3 SUBMITTALS

A. Submit shop drawings under provisions of Section 22 05 00.

B. Include products data with performance charts and curves for all equipment and components. Annotate descriptive data to show the specific model, type, and size of each item.

C. Include modeling report completed by Contractor. Modeling report shall be a Focus On Energy recognized modeling report equivalent to RetScreen, demonstrating the solar energy delivered with submitted equipment. Report to include 3% losses, 80% heat exchanger effectiveness.

1. Statements:

a. Prior to installation, submit data showing that this Contractor has successfully installed systems of the same type and design as specified herein.

2. Final Drawings and Data:

a. Collector Array Structural Information:

1) Prepare and submit shop drawings detailing the fabrication and erection of each solar collector and array. Include plans, elevations, sections, and details of the fabrications and their connections. Submittal shall include the seal of a qualified Professional Engineer who was responsible for their preparation.

b. Operating and Maintenance Manuals:

1) Submit manuals that detail the step-by-step procedures required for system filling, startup, operation, and shutdown. Include in the manuals the manufacturer's name, model number, service manual, parts list, and brief descriptions of all equipment and its basic operating features. List routine maintenance procedures, possible breakdowns and repairs, recommended spare parts, troubleshooting guide, piping and equipment layout, balanced fluid flow rates, and simplified wiring and control diagrams of the system as installed.

3. Field Test Reports:

a. Submit reports of piping hydraulic pressure test.
b. Submit reports of water potability test.
c. Submit results of system performance testing.

1.4 DEFINITIONS

A. The term "solar" for the purposes of this specification covers systems that intercept solar radiation and convert it to thermal energy. The thermal energy is collected by a heat transfer fluid and transferred through a heat exchanger to a thermal energy storage tank for use.

1.5 SYSTEM DESCRIPTION

A. Design Requirements:

1. Furnish and install new solar water heating (SHW) system for the pre-heating of domestic water. System types incorporating both freeze protection and overheat protection are required. Supplied equipment must be rated and warranted to withstand and operate below lowest-record-low and above highest-record-high temperature for the location.

2. Solar collectors are to be mounted where indicated on plans. System must be of a type suitable to the climate of the site.

3. Include, with system, components that consist of solar collector arrays, array support structure, storage tank, interconnecting piping and fittings, flush-and-fill valves, pressure relief valves, and, as required by the system type, any necessary pumps, controls or heat exchangers, as well as all other accessories and equipment required for the proper operation of the solar system.

4. Include with system all labor, supervision, equipment inside and outside the building, tools, materials, and incidentals necessary to design, procure, install, checkout, and place into operation a complete solar water heating system ready for use for the building.

B. Performance Requirements:

1. Solar water heating systems must be safe, reliable, require no operator intervention for normal operation, be visually unobtrusive, and be designed and installed in accordance with Focus On Energy Standards and Guidelines for solar water heating systems and all applicable state and local codes. The Contractor shall be responsible for providing a complete working solar system.

PART 2 - PRODUCTS

2.1 GENERAL EQUIPMENT REQUIREMENTS

A. Standard or Pre-approved Products:

1. Furnish materials and equipment that are the standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least six (6) months prior to bid opening. Collectors must be OG-100 rated, and packages must be OG-300 rated (SRCC).

B. Nameplates:

1. Secure to each major item of equipment a plate with the manufacturer's name, address, type or style, model or serial number, and catalog number.

2.2 PIPING SYSTEM

A. Provide a piping system complete with pipe, pipe fittings, valves, strainers, expansion loops, pipe hangers, inserts, supports, anchors, guides, sleeves, and accessories in accordance with this section and the drawings.

B. Pipe Material:

1. Tubing: Type L hard drawn seamless copper tube, ASTM B88.

2. Joints: Solder with 100% lead-free solder and flux, ASTM B32.

3. Fittings: Wrought copper solder joint, ANSI B16.22.

4. Valves and Accessories: Refer to Section 22 10 00 for performance requirements.

C. Pipe and Equipment Insulation:

1. Refer to Section 22 17 19 for insulation requirements on domestic water side of solar system.

2. Solar water supply and return piping shall be insulated as follows:

a. Provide elastomeric cellular foam insulation rated for 300°F. ANSI/ASTM C534; flexible plastic; 0.28 maximum 'K' value at 75ºF, 25/50 flame spread/smoke developed rating. Maximum 3/4" thick per layer where multiple layers are specified.

b. Where exposed to the outdoors, provide aluminum jacketing, plastic jacketing, or a Kraft-reinforced foil vapor barrier meeting the following requirements.

1) Aluminum Jackets: ASTM B209; 0.016" thick; stucco embossed finish with Z edge seams and aluminum bands for outdoor use. Where colored jacket covers are called for, provide factory-applied hard film acrylic paint in color selected by Architect.

2) Plastic Jackets and Fitting Covers: High impact, glossy white, 0.020” thick, self-extinguishing plastic. Suitable for use indoors or outdoors with ultraviolet inhibitors. Suitable for -40ºF to 150ºF. 25/50 maximum flame spread/smoke developed.

3) Kraft-reinforced foil vapor barrier with self-sealing adhesive joints. Beach puncture resistance ratio of at least 50 units. Tensile strength: 35 psi minimum. Single, self-seal acrylic adhesive on longitudinal jacket laps and butt strips.

4) Provide interior pipe insulation and coverings such as Armaflex, Insul-Tube, Rubatex, or approved equivalent. Provide outside array piping insulation with a capability of withstanding 250°F, except that piping insulation within 1.5 feet of collector connections shall be capable of withstanding 400°F. Protect outside piping insulation from water damage and ultraviolet degradation with a suitable outer coating manufactured for this purpose (aluminum, sunlight resistant PVC, Venture clad or approved equal).

D. Installation:

1. Provide, install, and test the piping and insulation in accordance with the following sections:

Section 22 05 00	Basic Plumbing Requirements
Section 22 05 29	Plumbing Supports and Anchors
Section 22 05 53	Plumbing Identification
Section 22 07 19	Plumbing Piping Insulation
Section 22 09 00	Instrumentation
Section 22 10 00	Plumbing Piping
Section 22 10 30	Plumbing Specialties

2.3 COLLECTOR SUBSYSTEM

A. Solar Collector Construction:

1. Collectors:

a. Manufacturers: Solar Skies, HTP, SunEarth, Alternate Energy Technologies, Heliodyne, Viessmann, or approved equal.
b. Type: Flat plate, SRCC approved; must be listed in RETScreen manufacturer list; SRCC clear day rating of at least 990 BTU/sq.ft of collector gross area at the "C" rating.
c. Absorber Coating: Blue-sputtered or selective surface (not black paint).
d. Glazing: Low iron tempered glass; with rubber gasket fitted to the edges; anti-glare finish.
e. Glazing Support: Fastener independent, compression type.
f. Glazing Gasket: Continuous U-shaped EPDM with molded corners.
g. Frame: All anodized extruded aluminum.
h. Backing: Aluminum sheet.
i. Fasteners: Stainless steel screws and other fastening hardware.
j. Header Connection: 1' machined brass Dyn-O-Seal unions with captive O-ring.
k. Header Grommets: Deep-grooved, wide-overlap EPDM.
l. Ventilation: Rain-shielded weep slots.
m. Insulation: Fiberglass over aluminum backed polyisocyanurate.
n. Mounting: Built-in mounting flange all around the perimeter.

2. Mounting Hardware:

a. Non-corroding aluminum for rails and stainless steel for washers, nuts, and bolts is to be used. Use all by manufacturer of collector and/or mounting hardware recommended parts.
b. Use manufacturer hardware for seam roof mounting, side rack mounting, vertical surface, and horizontal surface mounting.
c. Ballasted racks must be made of aluminum with stainless steel fasteners.

3. Furnish collectors of weathertight construction and with an aluminum casing. Provide aluminum or stainless steel mounting brackets and hinges. Furnish stainless steel assembly hardware including all bolts, washers, and nuts. Install collectors such that tubes on the absorber plate drain by gravity. Provide cover glazing completely replaceable from the front of the collector without disturbing the piping or adjacent collectors.

B. Collector Warranty:

1. Provide a minimum 10-year warranty against the following: failure of manifold or riser tubing, joints or fittings; degradation of absorber plate selective surface; rusting or discoloration of collector hardware; and embrittlement of header manifold seals. Include with the warranty full repair or replacement of defective materials or equipment.

C. Solar Collector Performance:

1. Plot thermal performance on the thermal efficiency curve in accordance with ASHRAE 93 showing the product of glazing transmittance and plate absorptivity and also the thermal loss coefficient (btu/hr/F) of the solar collector. Show manufacturer's recommended volumetric flow rate and the design pressure drop at the recommended flow rate. Indicate the manufacturer's recommendations for the number of collectors to be joined per bank while providing for balanced flow and for thermal expansion considerations.

2.4 SOLAR COLLECTOR ARRAY

A. Net Absorber Area and Array Layout:

1. Collector array shall be oriented so that all collectors face the same direction. Space collectors arranged in multiple rows so that no shading from other collectors is evident between 900 hours and 1500 hours solar time on December 21. Collectors should be south-facing and a tilt equal to or greater than the local latitude, but other orientations may be considered for approval. Collectors shall be tilted enough to prohibit snow accumulation.

B. Piping:

1. Connect interconnecting array piping between solar collectors in a reverse-return configuration, with approximately equal pipe length for any possible flow path. Indicate flow rate through the collector array. Provide each collector bank isolated by valves with a pressure relief valve and with the capability of being drained. Locate manually operated air vents at system high points, and pitch array piping so that piping can be drained by gravity. Supply calibrated balancing valves at the inlet of each collector bank as indicated.

2. All vents to have 1/4 turn shutoff ball valve. All vents and manual shutoff to be rated at 320°F or higher.

C. Supports for Solar Collector Array:

1. Provide support structure for the collector array of aluminum, stainless steel, hot dipped galvanized, or other corrosion-resistant approved material. Furnish a support structure that secures the collector array at the proper tilt angle with respect to horizontal and orientation with respect to true south. Provide a support structure that will withstand the static weight of filled collectors and piping, wind, and other anticipated loads without damage. System shall meet local and state building codes for wind and seismic loading for area of installation. Provide a support structure that allows access to all equipment for maintenance, repair, and replacement. Neoprene or EPDM washers shall separate all dissimilar metals. Coordinate support structure with Structural Engineer prior to ordering or fabricating.

2. Support system shall be design by a qualified Professional Engineer. Refer to Submittals section for requirements.

2.5 SOLAR EQUIPMENT

A. Domestic Hot Water Storage Tank – Glass Lined:

1. Tank: Steel, 125 psi working pressure, ASME stamped, with screwed stainless steel connections.

2. Line interior with corrosion resistant glass lining a minimum thickness of 0.39” thick.

3. Provide 11" x 15" access opening and steel support saddles or legs.

4. Provide tappings for accessories. Include tank drain, water inlet and outlet, 30°F to 200°F thermometer, and pressure relief valve suitable for maximum working pressure. Refer to drawings for additional tank openings.

5. Unit shall contain an integral heat exchanger as scheduled.

6. Acceptable Manufacturers: Heat Transfer Products, Badgerland, AO Smith, or approved equal.

B. Drainback Tank:

1. Tank: 304 stainless steel, 50 psig working pressure. Dent resistant plastic covering.

2. Provide site glass to monitor water level.

3. Provide tappings for accessories. Include water inlet and outlet, fill port, and sight window connections.

4. Acceptable Manufacturers: Solar Skies, Heat Transfer Products, Rheem, or approved equal.

C. Circulating Pumps:

1. Electrically-driven, single-stage, centrifugal type circulating pump. Support pumps on a concrete foundation or mounting intended for the purpose, or by the piping on which installed if appropriate to the size. Construct the pump shaft of corrosion resistant alloy steel with a mechanical seal. Control motors with switches that can be activated by either the differential temperature controller or by manual override (Hand-Off-Automatic). Pumps shall be installed with isolation valves so the pump can be serviced without draining the system.

2. Acceptable Manufacturers: B&G, Grundfos, Armstrong, or approved equal.

D. Air Separators:

1. Separators shall be ASME constructed and stamped for 125 psi working pressure and 350ºF operating temperature.

2. Air shall be separated by centrifugal force or coalescing action.

3. Provide openings for inlet, outlet, blowdown, and expansion tank.

4. Separators shall be line size or larger, with maximum pressure drop of 1 psi. Refer to drawing for separator sizing.

5. Acceptable Manufacturers: Amtrol, Armstrong, Spirotherm, Bell & Gossett, Wheatley, Patterson.

E. Heat Transfer Fluid:

1. Fluid shall be non-toxic (food grade) propylene glycol diluted with distilled water to 50% solution. Pure fluid has to be rated to withstand 350°F. Fluid must contain buffers to avoid acid build up as fluid deteriorates.

2. Acceptable Manufacturers: Dow frost HD or approved equal.

2.6 CONTROL AND INSTRUMENTATION SUBSYSTEM

1. Solar system will be controlled by the Facility Management Control System. Refer to mechanical drawings for additional information.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide, install and test the systems in accordance with the following sections:

Section 22 05 29	Plumbing Supports and Anchors
Section 22 05 53	Plumbing Identification
Section 22 07 19	Plumbing Piping Insulation
Section 22 09 00	Instrumentation
Section 22 10 00	Plumbing Piping
Section 22 10 30	Plumbing Specialties

B. System Flushing and Disinfection:

1. Flush the piping system.

C. Collector Array:

1. Install solar collector array at the proper tilt angle, orientation, and elevation above roof. Install the solar collectors with the ability to be removed for maintenance, repair, or replacement.

2. Install expansion arm of 6” copper pipe to buffer header expansion.

3. Bottom of collectors shall be a minimum of 2 feet above finished roof.

D. Array Piping:

1. Install collector array piping in a reverse-return configuration so that path lengths of collector supply and return are of approximately equal length. Install air vents in the high points of the collector array piping. Provide proper pitch for draining of collector array.

E. Array Support:

1. Install array support in accordance with the recommendations of the collector manufacturer.

F. Pipe Expansion:

1. Provide for the expansion and contraction of supply and return piping with changes in the direction of the run of pipe or by expansion loops. Do not use expansion joints in the system piping.

G. Valves:

1. Install ball valves at the inlet and outlet of each bank of manifolded collectors. Install calibrated balancing valves at the inlet of each collector bank and mark final settings on each valve. Balance flow through the collector piping with at least one balancing valve left in the open position.

H. Roof Penetrations:

1. All roof penetrations shall be made permanently waterproof. Copper or other approved flashing shall be used.

2. This Contractor shall provide a five (5)-year warranty on materials and labor, including consequential damages, for any roof leaks due to or arising out of the solar water heating system installation.

3. All pipe penetrations shall be protected with a UV-resistant rubber boot seal.

3.2 INSPECTION AND TESTING

A. Testing:

1. Refer to Section 22 10 00 for testing of the piping system.

B. Instructions:

1. Provide instructions for the system type. Include in these instructions a system schematic, and wiring and control diagrams showing the complete layout of the solar system. Prepare condensed operating instructions explaining preventative maintenance procedures, balanced flow rates, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system, in typed form, framed as specified above, and posted beside the diagrams. Post the framed instructions before acceptance testing of each system.

C. Operational Test:

1. Operationally test the system over a period of 48 consecutive hours with sufficient solar radiation to cause activation of the solar energy system during daylight hours.

D. Overall System Operations:

1. Demonstrate each solar energy system will operate properly while unattended for a period of at least 72 hours. As required by system design, demonstrate the system controller will start the pumps after being warmed by the sun and that it will properly shut down during cloudy weather or in the evening over a minimum of three complete cycles. It is permissible to manipulate the temperature of the storage tank by the introduction of cold water.

E. Temperature Sensor Diagnostics:

1. As required by system design, demonstrate the controller will correctly identify open and short circuits on both the solar collector temperature sensor circuit and the storage tank sensor circuit.

3.3 CLEANING

A. Refer to Section 22 10 00 for cleaning, installing, draining, venting, joining, and disinfecting of pipe.

3.4 FIELD TRAINING

A. Provide a field training course for operating and maintenance staff members after the system is functionally complete. Include in the training a discussion of the system design and layout, and demonstrate routine operation, maintenance and troubleshooting procedures.

END OF SECTION

SECTION 22 40 00
PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. All plumbing fixtures.

1.2 SUBMITTALS

A. Submit product data under provisions of Section 22 05 00. Submittals shall include fixture carriers for record purposes only. Architect/Engineer does not review or approve carriers except for manufacturer.

B. Include fixtures, sizes, rough-in dimensions, utility sizes, trim, and finishes.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Wall Hung Fixture Carriers:

1. Material: All Metal, ASME/ANSI A112.6.1M.

2. Acceptable Manufacturers: Zurn, Smith, Wade, Josam, Watts, Mifab.

3. Water closet carrier shall be rated to support 500 lbs. unless noted otherwise on the drawings.

B. All fixtures shall be as scheduled on the drawings.

C. All china shall be from the same manufacturer where possible.

D. All lavatory and sink trim shall be from the same manufacturer where possible.

E. All fixtures shall be lead free. Faucets, traps, stops, and other fixture accessories shall not contain more lead than allowed per the latest State or Federal Act.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Review millwork shop drawings. Confirm location and size of fixtures and openings before rough-in and installation.

2. Install each fixture with trap easily removable for servicing and cleaning. Use screwed tailpiece couplings. Connect fixture waste to stack with slip fitting.

3. Provide fixtures with chrome plated rigid or flexible supplies, loose key stops, reducers, and escutcheons.

4. Install components level and plumb.

5. Caulk joint between finish floor and floor mounted fixtures and between finish walls and wall mounted fixtures with silicon caulk. Caulk the joint, between rim and fixture where a fixture builds into a counter top, with caulking compound. Refer to DIVISION 7 for "Caulking" requirements. Color to match fixture.

6. Where there is a possibility of water following pipe brackets, etc., into a wall; caulk escutcheons, space around brackets, etc., to exclude water. Refer to DIVISION 7 for "Caulking" requirements.

7. Refer to Plumbing Material List for fixture mounting heights.

8. All non-potable outlets shall be clearly marked with a permanently affixed laminated sign with 3/8" high lettering saying "Non-Potable Water Not for Human Consumption." Sign shall have black lettering on a yellow background.

B. Wall-Mounted Fixture Requirements:

1. All wall-mounted fixtures shall have compatible carriers designed for their intended service and suitable for the space available and configuration of fixtures. All carriers shall extend to the floor and be anchored to the slab.

C. Floor-Mounted Fixture Requirements:

1. Where floor mounted fixtures are installed on a sloped floor, the open void below the fixture shall be grouted, leveled, and caulked to eliminate stress on the fixture and to prevent water migration to the floor below.

D. Exposed or Inside Accessible Cabinets Traps, Valve and Pipe Requirements:

1. All traps exposed under fixtures or inside accessible cabinets shall be chrome plated brass.

2. All water or waste piping for plumbing fixtures that is exposed or inside cabinets shall be chrome plated.

3. All exposed flush valves for water closets and urinals shall have a chrome plated hanger to anchor the piping to the wall.

4. All exposed water supply piping and fittings in a finished space to a shower valve, hose bibb, or other water outlet shall be chrome plated.

E. ADA Lavatory Requirements:

1. All handicapped accessible lavatory traps, piping and angle stops shall be installed with an insulating kit specially manufactured for this installation. Armaflex with duct tape is not acceptable.

F. ADA Water Closet Requirements:

1. Handicapped accessible water closet flush valve handles shall face the center of the stall.

2. Coordinate flush valves in handicap accessible locations with grab bars installed by the General Contractor. Make modifications required to flush valve after review by Architect/Engineer.

3.2 ADJUSTING AND CLEANING

A. Adjust stops or valves for intended water flow rate to fixtures without splashing, noise, or overflow.

B. At completion, clean plumbing fixtures, equipment, and faucet aerator screens.

3.3 FIXTURE ROUGH-IN SCHEDULE

A. Rough-in fixture piping connections in accordance with table on plumbing drawings of minimum sizes for particular fixtures.

END OF SECTION

SECTION 23 05 00
BASIC HVAC REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Requirements applicable to all Division 23 Sections. Also refer to Division 1 - General Requirements.

B. All materials and installation methods shall conform to the applicable standards, guidelines and codes referenced in the specification section.

1.2 SCOPE OF WORK

A. This Specification and the associated drawings govern the furnishing, installing, testing and placing into satisfactory operation the Mechanical Systems.

B. Each Contractor shall provide all new materials indicated on the drawings and/or in these specifications, and all items required to make his portion of the Mechanical Work a finished and working system.

C. All work will be awarded under a single General Contract. The division of work listed below is for the Contractor's convenience and lists normal breakdown of the work.

1.3 DIVISION OF WORK BETWEEN MECHANICAL, ELECTRICAL & CONTROL CONTRACTORS

A. Definitions:

1. "Mechanical Contractors" refers to the following:

   a. Plumbing Contractor.
   b. Heating Contractor.
   c. Air Conditioning and Ventilating Contractor.
   d. Temperature Control Contractor.
   e. Fire Protection Contractor.
   f. Testing, Adjusting, and Balancing Contractor.

2. Motor Control Wiring: The wiring associated with the remote operation of the magnetic coils of magnetic motor starters or relays, or the wiring that permits direct cycling of motors by means of devices in series with the motor power wiring. In the latter case the devices are usually single phase and are usually connected to the motor power wiring through a manual motor starter having "Manual-Off-Auto" provisions.

3. Control devices such as start-stop push buttons, thermostats, pressure switches, flow switches, relays, etc., generally represent the types of equipment associated with motor control wiring.

4. Motor control wiring is single phase and usually 120 volts. In some instances, the voltage will be the same as the motor power wiring. Generally, where the motor power wiring exceeds 120 volts, a control transformer is used to give a control voltage of 120 volts.

5. Temperature Control Wiring: The wiring associated with the operation of a motorized damper, solenoid valve or motorized valve, etc., either modulating or two-position, as opposed to wiring which directly powers or controls a motor used to drive equipment such as fans, pumps, etc.

   a. This wiring will be from a 120 volt source and may continue as 120 volt, or be reduced in voltage (24 volt) in which case a control transformer shall be furnished as part of the temperature control wiring.

6. Control Motor: An electric device used to operate dampers, valves, etc. It may be two-position or modulating. Conventional characteristics of such a motor are 24 volts, 60 cycles, 1 phase, although other voltages may be encountered.

B. General:

1. The purpose of these Specifications is to outline the Electrical and Mechanical Contractor's responsibilities related to electrical work required for items such as temperature controls, mechanical equipment, fans, chillers, compressors and the like. The exact wiring requirements for much of the equipment cannot be determined until the systems have been selected and submittals reviewed. Therefore, the electrical drawings show only known wiring related to such items. All wiring not shown on the electrical drawings, but required for mechanical systems, is the responsibility of the Mechanical Contractor.

2. Where the drawings require the Electrical Contractor to wire between equipment furnished by the Mechanical Contractor, such wiring shall terminate at terminals provided in the equipment. The Mechanical Contractor shall provide complete wiring diagrams and supervision to the Electrical Contractor and designate the terminal numbers for correct wiring.

3. All electrical work shall conform to the National Electrical Code. All provisions of the Electrical Specifications concerning wiring, protection, etc., apply to wiring provided by the Mechanical Contractor unless noted otherwise.

C. Mechanical Contractor's Responsibility:

1. Assumes responsibility for internal wiring of all equipment provided by the Mechanical Contractor, for example:

   a. Burners.
   b. Condensing Units.
   c. Makeup Air Units.
   d. Gas Trains.
   e. Package Air Handling Units.

2. Assumes all responsibility for the Temperature Control wiring, when the Temperature Control Contractor is a Subcontractor to the Mechanical Contractor.

3. Temperature Control Subcontractor's Responsibility:

   a. Wiring of all devices needed to make the Temperature Control System functional.

   b. Verifying any control wiring on the electrical drawings as being by the Electrical Contractor. All wiring required for the Control System, but not shown on the electrical drawings, is the responsibility of the Temperature Control Subcontractor.

   c. Coordinating equipment locations (such as relays, transformers, etc.) with the Electrical Contractor, where wiring of the equipment is by the Electrical Contractor.

4. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

D. Electrical Contractor's Responsibility:

1. Provides all combination starters, manual starters and disconnect devices shown on the Electrical Drawings or indicated to be by the Electrical Contractor on the Mechanical Drawings or Specifications.

2. Installs and wires all remote control devices furnished by the Mechanical Contractor or Temperature Control Subcontractor when so noted on the Electrical Drawings.

3. Provides motor control and temperature control wiring, where so noted on the drawings.

4. Furnishes, installs and connects all relays, etc., for automatic shutdown of certain fans upon actuation of the Fire Alarm System as indicated and specified in Division 28.

5. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

1.4 COORDINATION DRAWINGS

A. Definitions:

1. Coordination Drawings: A compilation of the pertinent layout and system drawings that show the sizes and locations, including elevations, of system components and required access areas to ensure that no two objects will occupy the same space.

a. Mechanical trades shall include, but are not limited to, mechanical equipment, ductwork, fire protection systems, plumbing piping, hydronic piping, and any item that may impact coordination with other disciplines.

b. Electrical trades shall include, but are not limited to, electrical equipment, conduit 1.5" and larger, conduit racks, cable trays, pull boxes, transformers, raceway, busway, lighting, ceiling-mounted devices, and any item that may impact coordination with other disciplines.

c. Technology trades shall include, but are not limited to, technology equipment, racks, conduit 1.5" and larger, conduit racks, cable trays, ladder rack, pull boxes, raceway, ceiling-mounted devices, and any item that may impact coordination with other disciplines.

d. Maintenance clearances and code-required dedicated space shall be included.

e. The coordination drawings shall include all underground, underfloor, in-floor, in chase, and vertical trade items.

2. The contractors shall use the coordination process to identify the proper sequence of installation of all utilities above ceilings and in other congested areas, to ensure an orderly and coordinated end result, and to provide adequate access for service and maintenance.

B. Participation:

1. The contractors and subcontractors responsible for work defined above shall participate in the coordination drawing process.

2. One contractor shall be designated as the Coordinating Contractor for purposes of preparing a complete set of composite electronic CAD coordination drawings that include all applicable trades, and for coordinating the activities related to this process. The Coordinating Contractor for this project shall be the HVAC Contractor.

a. The Coordinating Contractor shall utilize personnel familiar with requirements of this project and skilled as draftspersons/CAD operators, competent to prepare the required coordination drawings.

3. Electronic CAD drawings shall be submitted to the Coordinating Contractor for addition of work by other trades. KJWW will provide electronic file copies of ventilation drawings for contractor's use if the contractor signs and returns an "Electronic File Transfer" waiver provided by KJWW. KJWW will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings.

C. General:

1. Coordination drawing files shall be made available to the A/E and Owner's Representative. The A/E will only review identified conflicts and give an opinion, but will not perform as a coordinator.

2. A plotted set of coordination drawings shall be available at the project site.

3. Coordination drawings are not shop drawings and shall not be submitted as such.

4. The contract drawings are schematic in nature and do not show every fitting and appurtenance for each utility. Each contractor is expected to have included in his/her bid sufficient fittings, material, and labor to allow for adjustments in routing of utilities made necessary by the coordination process and to provide a complete and functional system.

5. The contractors will not be allowed additional costs or time extensions due to participation in the coordination process.

6. The contractors will not be allowed additional costs or time extensions for additional fittings, reroutings or changes of duct size, that are essentially equivalent sizes to those shown on the drawings and determined necessary through the coordination process.

7. The A/E reserves the right to determine space priority of equipment in the event of spatial conflicts or interference between equipment, piping, conduit, ducts, and equipment provided by the trades.

8. Changes to the contract documents that are necessary for systems installation and coordination shall be brought to the attention of the A/E.

9. Access panels shall preferably occur only in gypsum board walls or plaster ceilings where indicated on the drawings.

   a. Access to mechanical, electrical, technology, and other items located above the ceiling shall be through accessible lay-in ceiling tile areas.

   b. Potential layout changes shall be made to avoid additional access panels.

   c. Additional access panels shall not be allowed without written approval from the A/E at the coordination drawing stage.

   d. Providing additional access panels shall be considered after other alternatives are reviewed and discarded by the A/E and the Owner's Representative.

   e. When additional access panels are required, they shall be provided without additional cost to the Owner.

10. Complete the coordination drawing process and obtain sign off of the drawings by all contractors prior to installing any of the components.

11. Conflicts that result after the coordination drawings are signed off shall be the responsibility of the contractor or subcontractor who did not properly identify their work requirements, or installed their work without proper coordination.

12. Updated coordination drawings that reflect as-built conditions may be used as record documents.

1.5 QUALITY ASSURANCE

A. Contractor's Responsibility Prior to Submitting Pricing Data:

1. The Contractor is responsible for constructing complete and operating systems. The Contractor acknowledges and understands that the Contract Documents are a two-dimensional representation of a three-dimensional object, subject to human interpretation. This representation may include imperfect data, interpreted codes, utility guidelines, three-dimensional conflicts, and required field coordination items. Such deficiencies can be corrected when identified prior to ordering material and starting installation. The Contractor agrees to carefully study and compare the individual Contract Documents and report at once in writing to the Design Team any deficiencies the Contractor may discover. The Contractor further agrees to require each subcontractor to likewise study the documents and report at once any deficiencies discovered.

2. The Contractor shall resolve all reported deficiencies with the Architect/Engineer prior to awarding any subcontracts, ordering material, or starting any work with the Contractor's own employees. Any work performed prior to receipt of instructions from the Design Team will be done at the Contractor's risk.

B. Qualifications:

1. Only products of reputable manufacturers are acceptable.

2. All Contractors and subcontractors shall employ only workers skilled in their trades.

C. Compliance with Codes, Laws, Ordinances:

1. Conform to all requirements of the City of Madison, Wisconsin Codes, Laws, Ordinances and other regulations having jurisdiction.

2. Conform to all State Codes.

3. If there is a discrepancy between the codes and regulations and these specifications, the Architect/Engineer shall determine the method or equipment used.

4. If the Contractor notes, at the time of bidding, any parts of the drawings or specifications that do not comply with the codes or regulations, he shall inform the Architect/Engineer in writing, requesting a clarification. If there is insufficient time for this procedure, he shall submit with his proposal a separate price to make the system comply with the codes and regulations.

5. All changes to the system made after letting of the contract, to comply with codes or requirements of Inspectors, shall be made by the Contractor without cost to the Owner.

6. If there is a discrepancy between manufacturer's recommendations and these specifications, the manufacturer's recommendations shall govern.

7. All rotating shafts and/or equipment shall be completely guarded from all contact. Partial guards and/or guards that do not meet all applicable OSHA standards are not acceptable. Contractor is responsible for providing this guarding if it is not provided with the equipment supplied.

D. Permits, Fees, Taxes, Inspections:

1. Procure all applicable permits and licenses.

2. Abide by all laws, regulations, ordinances, and other rules of the State or Political Subdivision where the work is done, or as required by any duly constituted public authority.

3. Pay all charges for permits or licenses.

4. Pay all fees and taxes imposed by the State, Municipal and/or other regulatory bodies.

5. Pay all charges arising out of required inspections by an authorized body.

6. Pay all charges arising out of required contract document reviews associated with the project and as initiated by the Owner or authorized agency/consultant.

7. Where applicable, all fixtures, equipment and materials shall be approved or listed by Underwriter's Laboratories, Inc.

E. Examination of Drawings:

1. The drawings for the mechanical work are completely diagrammatic, intended to convey the scope of the work and to indicate the general arrangements and locations of equipment, outlets, etc., and the approximate sizes of equipment.

2. Contractor shall determine the exact locations of equipment and rough-ins, and the exact routing of pipes and ducts to best fit the layout of the job.

3. Scaling of the drawings is not sufficient or accurate for determining these locations.

4. Where job conditions require reasonable changes in indicated arrangements and locations, such changes shall be made by the Contractor at no additional cost to the Owner.

5. Because of the scale of the drawings, certain basic items, such as fittings, boxes, valves, unions, etc., may not be shown, but where required by other sections of the specifications or required for proper installation of the work, such items shall be furnished and installed.

6. If an item is either on the drawings or in the specifications, it shall be included in this contract.

7. Determination of quantities of material and equipment required shall be made by the Contractor from the documents. Where discrepancies arise between drawings, schedules and/or specifications, the greater number shall govern.

8. Where used in mechanical documents, the word "furnish" shall mean supply for use, the word "install" shall mean connect complete and ready for operation, and the word "provide" shall mean to supply for use and connect complete and ready for operation.

   a. Any item listed as furnished shall also be installed, unless otherwise noted.

   b. Any item listed as installed shall also be furnished, unless otherwise noted.

F. Field Measurements:

1. Verify all pertinent dimensions at the job site before ordering any materials or fabricating any supports, pipes or ducts.

G. Electronic Media/Files:

1. Construction drawings for this project have been prepared utilizing Revit.

2. Contractors and Subcontractors may request electronic media files of the contract drawings and/or copies of the specifications. Specifications will be provided in PDF format.

3. Upon request for electronic media, the Contractor shall complete and return a signed "Electronic File Transmittal" form provided by KJWW.

4. If the information requested includes floor plans prepared by others, the Contractor will be responsible for obtaining approval from the appropriate Design Professional for use of that part of the document.

5. The electronic contract documents can be used for preparation of shop drawings and as-built drawings only. The information may not be used in whole or in part for any other project.

6. The drawings prepared by KJWW for bidding purposes may not be used directly for ductwork layout drawings or coordination drawings.

7. The use of these electronic files by the Contractor does not relieve them from their responsibility for coordination of work with other trades and verification of space available for the installation.

8. The information is provided to expedite the project and assist the Contractor with no guarantee by KJWW as to the accuracy or correctness of the information provided. KJWW accepts no responsibility or liability for the Contractor's use of these documents.

1.6 SUBMITTALS

A. Submittals shall be required for the following items, and for additional items where required elsewhere in the specifications or on the drawings.

1. Submittals list:

Referenced Specification Section	Submittal Item
23 05 00	Owner Training Agenda
23 05 15	Variable Frequency Drives
23 05 48	HVAC Vibration Isolation
23 05 93	Testing, Adjusting, and Balancing
23 09 00	Controls
23 21 23	HVAC Pumps
23 25 00	Chemical Treatment Systems
23 36 00	Terminal Air Boxes
23 37 00	Commercial Type 1 Kitchen Hood
23 37 00	Grilles, Registers, and Diffusers
23 37 00	Louvers
23 52 16	Condensing Boilers
23 72 00	Energy Recovery Devices
23 73 13	Indoor Modular Air Handling Units
23 74 23.13	Gas Fired Make-Up Air Units
23 81 46	Packaged Water Source Heat Pumps
23 82 00	Terminal Heat Transfer Equipment
23 83 00	Radiant Floor Heating Systems

B. General Submittal Procedures: In addition to the provisions of Division 1, the following are required:

1. Transmittal: Each transmittal shall include the following:

a. Date
b. Project title and number
c. Contractor's name and address
d. Division of work (e.g., plumbing, heating, ventilating, etc.)
e. Description of items submitted and relevant specification number
f. Notations of deviations from the contract documents
g. Other pertinent data

2. Submittal Cover Sheet: Each submittal shall include a cover sheet containing:

   a. Date
   b. Project title and number
   c. Architect/Engineer
   d. Contractor and subcontractors' names and addresses
   e. Supplier and manufacturer's names and addresses
   f. Division of work (e.g., plumbing, heating, ventilating, etc.)
   g. Description of item submitted (using project nomenclature) and relevant specification number
   h. Notations of deviations from the contract documents
   i. Other pertinent data
   j. Provide space for Contractor's review stamps

3. Composition:

   a. Submittals shall be submitted using specification sections and the project nomenclature for each item.

   b. Individual submittal packages shall be prepared for items in each specification section. All items within a single specification section shall be packaged together where possible. An individual submittal may contain items from multiple specifications sections if the items are intimately linked (e.g., pumps and motors).

   c. All sets shall contain an index of the items enclosed with a general topic description on the cover.

4. Content: Submittals shall include all fabrication, erection, layout, and setting drawings; manufacturers' standard drawings; schedules; descriptive literature, catalogs and brochures; performance and test data; wiring and control diagrams; dimensions; shipping and operating weights; shipping splits; service clearances; and all other drawings and descriptive data of materials of construction as may be required to show that the materials, equipment or systems and the location thereof conform to the requirements of the contract documents.

5. Contractor's Approval Stamp:

   a. The Contractor shall thoroughly review and approve all shop drawings before submitting them to the Architect/Engineer. The Contractor shall stamp, date and sign each submittal certifying it has been reviewed.

   b. Unstamped submittals will be rejected.

   c. The Contractor's review shall include, but not be limited to, verification of the following:

      1) Only approved manufacturers are used.
      2) Addenda items have been incorporated.
      3) Catalog numbers and options match those specified.
      4) Performance data matches that specified.
      5) Electrical characteristics and loads match those specified.
      6) Equipment connection locations, sizes, capacities, etc. have been coordinated with other affected trades.
      7) Dimensions and service clearances are suitable for the intended location.
      8) Equipment dimensions are coordinated with support steel, housekeeping pads, openings, etc.
      9) Constructability issues are resolved (e.g., weights and dimensions are suitable for getting the item into the building and into place, sinks fit into countertops, etc.).

d. The Contractor shall review, stamp and approve all subcontractors' submittals as described above.

e. **The Contractor's approval stamp is required on all submittals. Approval will indicate the Contractor's review of all material and a complete understanding of exactly what is to be furnished. Contractor shall clearly mark all deviations from the contract documents on all submittals. If deviations are not marked by the Contractor, then the item shall be required to meet all drawing and specification requirements.**

6. Submittal Identification and Markings:

a. The Contractor shall clearly mark each item with the same nomenclature applied on the drawings or in the specifications.

b. The Contractor shall clearly indicate the size, finish, material, etc.

c. Where more than one model is shown on a manufacturer's sheet, the Contractor shall clearly indicate exactly which item and which data is intended.

d. All marks and identifications on the submittals shall be unambiguous.

7. Schedule submittals to expedite the project. Coordinate submission of related items.

8. Identify variations from the contract documents and product or system limitations that may be detrimental to the successful performance of the completed work.

9. Reproduction of contract documents alone is not acceptable for submittals.

10. Incomplete submittals will be rejected without review. Partial submittals will only be reviewed with prior approval from the Architect/Engineer.

11. Submittals not required by the contract documents may be returned without review.

12. The Architect/Engineer's responsibility shall be to review one set of shop drawing submittals for each product. If the first submittal is incomplete or does not comply with the drawings and/or specifications, the Contractor shall be responsible to bear the cost for the Architect/Engineer to recheck and handle the additional shop drawing submittals.

13. Submittals shall be reviewed and approved by the Architect/Engineer **before** releasing any equipment for manufacture or shipment.

14. Contractor's responsibility for errors, omissions or deviation from the contract documents in submittals is not relieved by the Architect/Engineer's approval.

C. Electronic Submittal Procedures:

1. Distribution: Email submittals as attachments to all parties designated by the Architect/Engineer, unless a web-based submittal program is used.

2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.

3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.

4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

    a. Submittal file name: 23 XX XX.description.YYYYMMDD
    b. Transmittal file name: 23 XX XX.description.YYYYMMDD

5. File Size: Electronic file size shall be limited to a maximum of 4MB. Larger files shall be transmitted via a pre-approved method.

1.7 EQUIPMENT SUPPLIERS' INSPECTION

A. The following equipment shall not be placed in operation until a competent installation and service representative of the manufacturer has inspected the installation and certified that the equipment is properly installed, adjusted and lubricated; that preliminary operating instructions have been given; and that the equipment is ready for operation:

1. Inline Pumps
2. Boilers, Burners and Boiler Trim
3. Water Source Heat Pumps
4. Gas Fired Makeup Air Units
5. Air Handling Units
6. Energy Recovery Units

B. Contractor shall arrange for and obtain supplier's on-site inspection(s) at proper time(s) to assure each phase of equipment installation and/or connection is in accordance with the manufacturer's instructions.

C. Submit copies of start-up reports to the Architect/Engineer and include copies of Owner’s Operation and Maintenance Manuals.

1.8 PRODUCT DELIVERY, STORAGE, HANDLING & MAINTENANCE

A. Exercise care in transporting and handling to avoid damage to materials. Store materials on the site to prevent damage. Keep materials clean, dry and free from harmful conditions. Immediately remove any materials that become wet or that are suspected of becoming contaminated with mold or other organisms.

B. Keep all bearings properly lubricated and all belts properly tensioned and aligned.

C. Coordinate the installation of heavy and large equipment with the General Contractor and/or Owner. If the Mechanical Contractor does not have prior documented experience in rigging and lifting similar equipment, he/she shall contract with a qualified lifting and rigging service that has similar documented experience. Follow all equipment lifting and support guidelines for handling and moving.

D. Contractor is responsible for moving equipment into the building and/or site. Contractor shall review site prior to bid for path locations and any required building modifications to allow movement of equipment. Contractor shall coordinate his/her work with other trades.

1.9 WARRANTY

A. Refer to Division 01 specification for requirements.

1.10 MATERIAL SUBSTITUTION

A. Refer to Division 01 specification for requirements.

1.11 LEED REQUIREMENTS

A. This project is pursuing a LEED Silver certification in accordance with USGBC LEED Rating System for New Construction Version 2009. The Contractor shall provide all services and documentation necessary to achieve this rating.

B. Refer to Division 01 specification for requirements.

1.12 PROJECT COMMISSIONING

A. The Contractor shall work with the Commissioning Agent (CxA) as described in Section 01 91 00, and provide all services necessary for compliance with LEED Prerequisite EAp1, Fundamental Commissioning, and EAc3 Enhanced Commissioning.

PART 2 - PRODUCTS

NOT APPLICABLE

PART 3 - EXECUTION

3.1 JOBSITE SAFETY

A. Neither the professional activities of the Architect/Engineer, nor the presence of the Architect/Engineer or his or her employee and subconsultants at a construction site, shall relieve the Contractor and other entity of their obligations, duties and responsibilities including, but not limited to, construction means, methods, sequence, techniques or procedures necessary for performing, superintending or coordinating all portions of the work of construction in accordance with the contract documents and any health or safety precautions required by any regulatory agencies. The Architect/Engineer and his or her personnel have no authority to exercise any control over any construction contractor or other entity or their employees in connection with their work or any health or safety precautions. The Contractor is solely responsible for jobsite safety. The Architect/Engineer and the Architect/Engineer's consultants shall be indemnified and shall be made additional insureds under the Contractor's general liability insurance policy.

3.2 OPERATION AND MAINTENANCE MANUALS

A. Refer to Division 01 specification for requirements.

3.3 INSTRUCTING THE OWNER'S REPRESENTATIVES

A. Adequately instruct the Owner's designated representatives in the maintenance, care, and operation of all systems installed under this contract per specification 01 79 00.

B. The instructions shall include:

1. Explanation of all system flow diagrams.
2. Explanation of all air handling systems.
3. Temperature control system operation including calibration, adjustment and proper operating conditions of all sensors.
4. Maintenance of equipment.
5. Start-up procedures for all major equipment.
6. Explanation of seasonal system changes.
7. Description of emergency system operation.

C. Minimum hours of instruction for each item shall be:

1. Heating Water System - 4 hours.

2. Refrigeration System - 2 hours.
3. Chemical Treatment System - As defined in Section 23 25 00.
4. Air Handling System(s) - 2 hours.
5. Temperature Controls - As defined in Section 23 09 00.

3.4 SYSTEM COMMISSIONING

A. Refer to specification 01 91 00 for additional requirements.

B. The mechanical systems shall be complete and operating. System start-up, testing, balancing, and satisfactory system performance is the responsibility of the Contractor. This includes calibration and adjustments of all controls, noise level adjustments and final comfort adjustments as required.

C. Operate all HVAC systems continuously for at least one week prior to occupancy to bring construction materials to suitable moisture levels. Areas with mechanical cooling shall be maintained below 60% RH.

D. Contractor shall adjust the mechanical systems and controls at season changes during the one year warranty period, as required, to provide satisfactory operation and to prove performance of all systems in all seasons.

E. All operating conditions and control sequences shall be tested during the start-up period. Test all interlocks, safety shutdowns, controls, and alarms.

F. The Contractor, subcontractors, and equipment suppliers shall have skilled technicians to ensure that all systems perform properly. If the Architect/Engineer is requested to visit the job site for trouble shooting, assisting in start-up, obtaining satisfactory equipment operation, resolving installation and/or workmanship problems, equipment substitution issues or unsatisfactory system performance, including call backs during the warranty period, through no fault of the design; the Contractor shall reimburse the Owner on a time and materials basis for services rendered at the Architect/Engineer's standard hourly rates in effect when the services are requested. The Contractor shall pay the Owner for services required that are product, installation or workmanship related. Payment is due within 30 days after services are rendered.

3.5 RECORD DOCUMENTS

A. The following paragraph supplements Division 1 requirements:

Contractor shall maintain at the job site a separate and complete set of mechanical drawings and specifications on which he shall clearly and permanently mark in complete detail all changes made to the mechanical systems.

B. Mark drawings to indicate revisions to piping and ductwork, size and location, both exterior and interior; including locations of coils, dampers, other control devices, filters, and other units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned from column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (e.g., traps, strainers, expansion compensators, tanks, etc.); Change Orders; concealed control system devices.

C. Refer to Section 23 09 00 for additional requirements for Temperature Control documents.

D. Mark specifications to show approved substitutions; Change Orders, and actual equipment and materials used.

E. Record changes daily and keep the marked drawings available for the Architect/Engineer's examination at any normal work time.

F. Upon completing the job, and before final payment is made, give the marked-up drawings to the Architect/Engineer.

3.6 ADJUST AND CLEAN

A. Thoroughly clean all equipment and systems prior to the Owner's final acceptance of the project. Clean all foreign paint, grease, oil, dirt, labels, stickers, and other foreign material from all equipment.

B. Clean all drain pans and areas where moisture is present. Immediately report any mold, biological growth, or water damage.

C. Remove all rubbish, debris, etc., accumulated during construction from the premises.

3.7 CONSTRUCTION WASTE MANAGEMENT

A. This Contractor shall comply with all construction and demolition waste disposal and recycling requirements outlined in LEED MRc2: Construction Waste Management (follow latest edition at the time of bidding or as referenced in these specifications).

1. This Contractor shall coordinate with the General Contractor to develop and implement a construction waste management plan that, at a minimum, identifies the materials to be diverted from disposal and whether the materials will be sorted on-site or co-mingled.

2. The Contractor shall track waste disposal and recycling efforts throughout the construction process for all materials associated with this Contractor’s scope of work. The Contractor shall provide this information to the General Contractor so that it can be incorporated with similar information from all other contractors for the project.

    a. Calculations for waste and recycled material can be done by weight or volume, but they must be consistent throughout the project. The Contractor shall coordinate with the General Contractor to establish the preferred calculation method and report the results accordingly.

    b. Excavated soil and land-clearing debris do not count towards the waste disposal or recycled material.

3. At a minimum, 50% of the construction and demolition debris for this project must be recycled or salvaged.

END OF SECTION

READINESS CERTIFICATION PRIOR TO FINAL JOBSITE OBSERVATION

In order to prevent the final job observation from occurring too early, we require that the Contractor review the completion status of the project and, by copy of this document, certify that the job is indeed ready for the final job observation. The following is a typical list of items that represent the degree of job completeness expected prior to your requesting a final job observation.

1. All air handling units operating and balanced.
2. All fans shall be operating and balanced.
3. All pumps, boilers operating and balanced.
4. All miscellaneous mechanical systems (unit heaters, fan coil units, cabinet heaters, etc.) operating.
5. All temperature control systems operating, programmed and calibrated.
6. Pipe insulation complete, pipes labeled and valves tagged.
7. Fire damper and fire/smoke damper access doors labeled in accordance with specifications.

Accepted by:

Prime Contractor _____

By _____ Date _____

Upon Contractor certification that the project is complete and ready for a final job observation, we require the Contractor to sign this agreement and return it to the Architect/Engineer so that the final observation can be scheduled.

It is understood that if the Architect/Engineer finds the job not ready for the final observation and that additional trips and observations are required to bring the project to completion, the costs incurred by the Architect/Engineers for additional time and expenses will be deducted from the Contractor's contract retainage prior to final payment at the completion of the job.

* * * * *

SECTION 23 05 13
MOTORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Single Phase and Three Phase Electric Motors.

1.2 DELIVERY, STORAGE, AND HANDLING

A. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weatherproof coverings. For extended outdoor storage, follow manufacturer's recommendations for equipment and motor.

1.3 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data including assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.4 QUALIFICATIONS

A. Manufacturer: Company specializing in the manufacture of commercial and industrial motors and accessories, with a minimum of three years documented manufacturing experience.

PART 2 - PRODUCTS

2.1 MOTORS - GENERAL CONSTRUCTION AND REQUIREMENTS

A. Refer to the drawings for required electrical characteristics.

B. Design motors for continuous operation in 40ºC environment, and for temperature rise in accordance with ANSI/NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.

C. Visible Nameplate: Indicating horsepower, voltage, phase, hertz, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor, insulation class.

D. Electrical Connection: Boxes, threaded for conduit. For fractional horsepower motors where connection is made directly, provide conduit connection in end frame.

E. Unless otherwise indicated, motors 1 HP and larger shall be three phase, 60 hertz, squirrel cage type, NEMA Design Code B (low current in-rush, normal starting torque), totally enclosed fan-cooled type.

F. Each contractor shall set all motors furnished by him.

G. All motors shall have a minimum service factor of 1.15.

H. All motors shall have ball or roller bearings with a minimum L-10 fatigue life of 150,000 hours in direct-coupled applications and 50,000 hours for belted applications. Belted rating shall be based on radial loads and pulley sizes called out in NEMA MG1-14.43.

I. Bearings shall be sealed type for 10 HP and smaller motors. Bearings shall be regreasable type for larger motors.

J. Aluminum end housings are not permitted on motors 15 HP or larger.

K. Provide all belted motors with a means of moving and securing the motor to tighten belts. Motors over 2 HP shall have screw type tension adjustment. Motors over 40 HP shall have dual screw adjusters. Slide bases shall conform to NEMA standards.

L. Motors for fans and pumps 1/12 HP or greater and less than 1 HP shall be electronically-commutated motors or shall have a minimum motor efficiency of 70% when rated in accordance with DOE 10 CFR 431. These motors shall also have the means to adjust motor speed for either balancing or remote control. Belt-driven fans may use sheave adjustments for airflow balancing in lieu of varying motor speed. Motors shall be single phase, 60 hertz.

2.2 PREMIUM EFFICIENCY MOTORS (INCLUDING MOST 3-PHASE GENERAL PURPOSE MOTORS)

A. All motors, unless exempted by EPAct legislation that became federal law on December 19, 2010, shall comply with the efficiencies listed in that standard, which are reprinted below. These match the 2010 NEMA premium efficiency ratings. All ratings listed are nominal full load efficiencies, verified in accordance with IEEE Standard 112, Test Method B. Average expected (not guaranteed minimum) power factors shall also be at least the following:

	Full-Load Efficiencies %					
	Open Drip-Proof			Totally Enclosed Fan Cooled		
HP	1200 rpm	1800 rpm	3600 rpm	1200 rpm	1800 rpm	3600 rpm
1.0	82.5	85.5	77.0	82.5	85.5	77.0
1.5	86.5	86.5	84.0	87.5	86.5	84.0
2.0	87.5	86.5	85.5	88.5	86.5	85.5
3.0	88.5	89.5	85.5	89.5	89.5	86.5
5.0	89.5	89.5	86.5	89.5	89.5	88.5
7.5	90.2	91.0	88.5	91.0	91.7	89.5
10.0	91.7	91.7	89.5	91.0	91.7	90.2
15.0	91.7	93.0	90.2	91.7	92.4	91.0
20.0	92.4	93.0	91.0	91.7	93.0	91.0
25.0	93.0	93.6	91.7	93.0	93.6	91.7
30.0	93.6	94.1	91.7	93.0	93.6	91.7
40.0	94.1	94.1	92.4	94.1	94.1	92.4
50.0	94.1	94.5	93.0	94.1	94.5	93.0
60.0	94.5	95.0	93.6	94.5	95.0	93.6
75.0	94.5	95.0	93.6	94.5	95.4	93.6
100.0	95.0	95.4	93.6	95.0	95.4	94.1
125.0	95.0	95.4	94.1	95.0	95.4	95.0
150.0	95.4	95.8	94.1	95.8	95.8	95.0
200.0	95.4	95.8	95.0	95.8	96.2	95.4
250.0	95.4	95.8	95.0	95.8	96.2	95.8
300.0	95.4	95.8	95.4	95.8	96.2	95.8
350.0	95.4	95.8	95.4	95.8	96.2	95.8
400.0	95.8	95.8	95.8	95.8	96.2	95.8
450.0	96.2	96.2	95.8	95.8	96.2	95.8
500.0	96.2	96.2	95.8	95.8	96.2	95.8

B. Motor nameplate shall be noted with the above ratings.

2.3 MOTORS ON VARIABLE FREQUENCY DRIVES

A. All motors driven by VFDs shall be premium efficiency type.

B. Motors shall be designed for use with VFDs in variable torque applications with 1.15 service factor. Motors shall not be equipped with auxiliary blowers.

C. Motors driven by VFDs shall have Class F or H insulation and be designated by the motor manufacturer to be suitable for inverter duty service in accordance with NEMA MG 1 Section IV, "Performance Standards Applying to All Machines," Part 31 "Definite-Purpose Inverter-Fed Polyphase Motors.

A. All 460 volt motors controlled by VFDs shall be equipped with an alternate discharge path, such as a shaft grounding ring or grounding brush, to divert adverse shaft currents from the motor bearings on the drive end of the motor shaft. Motor shafts 2" and larger require shaft grounding on the drive end and the non-drive end. This Contractor shall ensure (via field observation and measurement) that the shaft is effectively grounded upon startup.

1. Providing grounding rings internal to the motor housing is an acceptable solution, provided the motor is affixed with a label clearly indicating the presence of a grounding assembly. The grounding ring shall be listed for 40,000 hours of motor service and shall be accessible via the drive endplate.

2.4 MOTOR DRIVEN EQUIPMENT

A. No equipment shall be selected or operate above 90% of its motor nameplate rating. Motor size may not be increased to compensate for equipment with efficiency lower than that specified.

B. If a larger motor than specified is required on equipment, the contractor supplying the equipment is responsible for all additional costs due to larger starters, wiring, etc.

2.5 SHEAVES

A. All sheaves shall conform to NEMA Standard MG1-14.42, which lists minimum diameters and maximum overhangs. Locate motors to minimize overhang.

B. When replacing sheaves, use sheaves of at least the originally supplied sizes.

C. Contractor responsible for motor shall also be responsible for replacement sheaves. Coordinate with testing and balancing of the equipment.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All rotating shafts and/or equipment shall be completely guarded from all contact. Partial guards and/or guards that do not meet all applicable OSHA standards are not acceptable. Contractor is responsible for providing this guarding if it is not provided with the equipment supplied.

B. For flexible coupled drive motors, mount coupling to the shafts in accordance with the coupling manufacturer's recommendations. Align shafts to manufacturer's requirements or within 0.002 inch per inch diameter of coupling hub.

C. For belt drive motors, mount sheaves on the appropriate shafts per manufacturer's instructions. Use a straight edge to check alignment of the sheaves. Reposition sheaves as necessary so the straight edge contacts both sheave faces squarely. After sheaves are aligned, loosen the adjustable motor base so the belt(s) can be added, and tighten the base so the belt tension is in accordance with the drive manufacturer's recommendations. Frequently check belt tension and adjust if necessary during the first day of operation and again after 80 hours of operation.

END OF SECTION

SECTION 23 05 15
VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Variable frequency drives

1.2 RELATED SECTIONS AND WORK

A. Refer to the Variable Frequency Drive Schedule for rating and configuration.

1.3 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 23 05 00.

B. Shop Drawings: Include front and side views of enclosures with overall dimensions and weights shown; conduit entrance locations and requirements; and nameplate legends.

C. Product Data: Provide catalog sheets showing voltage, controller size, ratings and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details.

D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

E. Provide harmonic distortion analysis of total service to prove variable frequency drives proposed do not exceed the latest version of IEEE 519 voltage and current distortion limits as shown in Table 10.2 and 10.3 at the point of common coupling (PCC). The PCC shall be defined as the consumer-utility interface or primary side of the main distribution transformer.

1.4 EXTRA MATERIAL

A. Furnish under provisions of Section 23 05 00.

B. Provide two of each air filter.

C. Provide three of each fuse size and type.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under provisions of Section 23 05 00.

B. Accept controllers on site in original packing. Inspect for damage.

C. 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.

D. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 23 05 00.

B. Maintenance Data: Include spare parts data listing, source and current prices of replacement parts and supplies, and recommended maintenance procedures and intervals.

C. Operation Data: Include instructions for starting and operating controllers, and describe operating limits that may result in hazardous or unsafe conditions.

D. Shop Drawings: For each VFD.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:

a. Each installed unit's type and details.

b. Nameplate legends.

c. Short-circuit current rating of integrated unit.

d. UL listing for series rating of overcurrent protective devices in combination controllers.

e. Features, characteristics, ratings, and factory settings of each motor-control center unit.

2. Wiring Diagrams: Power, signal, and control wiring for VFDs. Provide schematic wiring diagram for each type of VFD.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS: DANFOSS

2.2 DESCRIPTION

A. Converts 60 Hertz input power at voltage specified to a variable AC frequency and voltage for controlling the speed of AC squirrel cage motors. The controller shall be suitable for use with standard NEMA B squirrel cage 1.15 service factor induction motors without requiring any modifications to the motor or the drive.

B. Controller shall have sufficient capacity to provide speed control of the motors shown or noted throughout the specified environmental operating conditions.

C. Controller shall have the functional components listed below:

1. Door interlocked input circuit breaker/fused switch.
2. Input rectifier section to supply fixed DC bus voltage.
3. Smoothing reactor for DC bus.
4. DC bus capacitors.
5. Control transformer.
6. Separate terminal blocks for power and control wiring.
7. Terminal block for operator controls.
8. Sine weighted PWM generating inverter section.

2.3 RATINGS

A. Rated Input Voltage: Refer to mechanical equipment schedule for motor requirements.

B. Motor Nameplate (Drive Output) Voltage: Refer to Mechanical Schedules.

C. Displacement Power Factor: Between 1.0 and 0.95, lagging, over entire range of operating speed and load.

D. Operating Ambient: 0°C to 40°C.

E. Minimum Relative Humidity Range: 5% to 90% (non-condensing).

F. Minimum Elevation without Derating: 3300 feet.

G. Minimum Efficiency at Full Load: 96 percent.

H. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds or 180% for 0.5 seconds.

I. Starting Torque: 100 percent of rated torque or as indicated.

J. Speed Regulation: Plus or minus 1 percent with no motor derating.

2.4 DESIGN

A. Pulse Width Modulated (PWM) Variable Frequency Drives:

1. Converter shall be of a diode bridge design with a sine-weighted PWM inverter section.

2. Main semi-conductors in the inverter section of controller shall be IGBT transistors capable of a carrier switching frequency of up to 8 kHz. If derating of the inverter is necessary to run at 8kHz, then the unit's derated currents must equal or exceed the motor full load currents listed in NEC Table 430-150.

3. All controllers supplied with semi-conductors capable of switching at less than 8,000 Hertz shall be supplied with a motor acoustic noise reduction filter.

4. Pulse width modulated (PWM) drives shall be supplied with drive input line reactors with a minimum impedance of 3%. Reactors shall be installed to filter entire drive input circuit.

5. Pulse width modulated (PWM) drives shall be supplied with drive input harmonic filter to reduce the total harmonic distortion to less than the IEEE519-1992 limits at the utility service entrance.

6. Drives that are located beyond the manufacturer's recommended maximum distance from the motor shall be provided with dV/dt (long lead) filters.

B. All drives shall have built-in diagnostic capability with status and fault indicators mounted on enclosure door. Complete operating instructions for diagnostics shall be mounted inside of the enclosure door.

C. Drive shall restart after power loss and under-voltage fault. The minimum number of restart attempts required shall be three, field adjustable.

D. The drive shall allow unlimited switching of the output without damage to the drive or motor.

2.5 PRODUCT FEATURES

A. Display: Provide integral digital display to indicate all protection faults and drive status (including overcurrent, overvoltage, undervoltage, ground fault, overtemperature, phase loss, input power ON, output voltage, output frequency, and output current.

B. Protection:

1. Input transient protection by means of surge suppressors.

2. Snubber networks to protect against malfunctions due to system transients,

3. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.

4. Motor thermal overload relay(s) adjustable and capable of NEMA Class 20 motor protection and sized per motor nameplate data. When multiple motors are connected to the VFD output, each motor shall have a manual starter with properly sized overload protection.

5. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.

6. Instantaneous line-to-line and line-to-ground overcurrent trips on input and output.

7. Loss-of-phase protection.

8. Reverse-phase protection.

9. Short-circuit protection (fuses or circuit breaker).

10. Motor overtemperature fault.

C. Acceleration Rate Adjustment: 0.5 - 30 seconds.

D. Deceleration Rate Adjustment: 1 - 30 seconds.

E. Minimum Adjustment Range for the Lower Output Frequency shall be: 0 to 40 Hertz.

F. Minimum Adjustment Range for the Upper Output Frequency Range shall be: 40 to 90 Hertz.

G. Minimum Volts/Hertz Range: 3.7 to 8.6 volts/Hertz.

H. Provide MANUAL-OFF-AUTOMATIC selector switch and manual analog speed control mounted on the front of the enclosure.

I. Safety Interlocks: Provide terminals for remote contact to inhibit starting under both manual and automatic mode.

J. Control Interlocks: Provide terminals for remote contact to allow starting in automatic mode.

K. Provide adjustable skip frequencies on the drive output (minimum of three ranges).

L. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption, and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.

M. Power-Interruption Protection: After a power interruption, it prevents the motor from re-energizing until the motor has stopped.

N. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

O. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

P. Status Lights: Door-mounted LED indicators shall indicate the following conditions:

1. Power on.
2. Run.
3. Overvoltage.

4. Line fault.
5. Overcurrent.
6. External fault.

Q. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.

R. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (VDC).
9. Set-point frequency (Hz).
10. Motor output voltage (V).

S. Control Signal Interface:

1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.

2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:

a. 0 to 10-V dc.
b. 0-20 or 4-20 mA.
c. Potentiometer using up/down digital inputs.
d. Fixed frequencies using digital inputs.
e. RS485.
f. Keypad display for local hand operation.

3. Output Signal Interface:

a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:

1) Output frequency (Hz).
2) Output current (load).
3) DC-link voltage (VDC).
4) Motor torque (percent).
5) Motor speed (rpm).
6) Set-point frequency (Hz).

4. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1A) for remote indication of the following:

a. Motor running.
b. Set-point speed reached.
c. Fault and warning indication (overtemperature or overcurrent).
d. PID high- or low-speed limits reached.

T. Communications: Provide a communications card to interface VFD with Facility Management Control System (FMCS). Coordinate interface requirements with the FMCS provided under Section 23 09 00. Interface shall allow all parameter settings of VFD to be programmed via FMCS control and displayed on FMCS operator workstation. Provide capability for VFD to retain these settings within the nonvolatile memory.

U. Three-Contactor Manual Bypass:

1. Provide contactors, motor running overload protection, under-voltage and loss of phase protection, and short circuit protection for full voltage, non-reversing operation of the motor. Include isolation switch or third contactor to allow maintenance of inverter during bypass operation.

2. All bypass circuitry shall be located within the same enclosure as the variable frequency drive.

3. All fire alarm and/or smoke control interconnections (e.g., air handling unit shutdown) shall apply regardless of whether control is through VFD or bypass.

4. Provide a Drive-Bypass Selector Switch.

5. Provide nameplate with instructions for switching from drive to bypass and from bypass to drive. Provide instructions for isolating VFD for maintenance.

V. Control:

1. With the "Manual-Off-Auto" switch in the "Manual" position and, if applicable, the "Drive-Bypass" in the "Drive" position, the drive shall be controlled by the manual speed potentiometer on the drive door.

2. With the "Manual-Off-Auto" switch in the "Auto" position and, if applicable, the "Drive-Bypass" in the "Drive" position, the drive shall be controlled by the input signal from an external source.

3. If applicable, with the "Drive-Bypass" in the "Bypass" position, regardless the position of the "Manual-Off-Auto" switch, the motor shall be connected across the lines and shall be run at full speed.

4. With the "Manual-Off-Auto" switch in the "Off" position, if applicable, the drive run circuit shall be open and the VFD shall not operate.

5. If applicable, signal from the fire alarm control panel shall shut down VFD and bypass.

6. All disconnect switches between VFD and motor(s) shall include an auxiliary contact interlock wired to the VFD fault trip input to shut down the drive upon opening of the disconnect main contacts.

2.6 ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

B. All VFD supplied for fans shall have dynamic or DC injection braking capability to provide a means of rapid deceleration of the AC motor in not more than one (1) minute. Adjust controls to stop the motor within 30 seconds.

C. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.

D. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

E. Control Relays: Auxiliary and adjustable time-delay relays.

F. Standard Displays:

1. Output frequency (Hz).
2. Set-point frequency (Hz).
3. Motor current (amperes).
4. DC-link voltage (VDC).
5. Motor torque (percent).
6. Motor speed (rpm).
7. Motor output voltage (V).

G. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

H. Fabrication:

1. Enclosure: NEMA 250, Type 1.
2. Finish: Manufacturer's standard enamel.

PART 3 - EXECUTION

3.1 FACTORY TESTING

A. The VFD manufacturer shall provide certification that heat test has been completed.

B. The Electrical Contractor shall have a factory service engineer present for the start-up, field calibration, and check-out of each VFD installed. Factory service engineer shall be required to return to the site for recalibration or set-up should unit not function as specified during system commissioning. All costs shall be a part of This Contract. Provide tag with date and signature of factory service Engineer on inside cover of each drive.

3.2 INSTALLATION

A. Install variable frequency drive equipment in accordance with the manufacturer's instructions.

B. Floor mount VFD on prefabricated or field fabricated supports with controls no higher than 6'-6" and no lower than 3'-0" AFF. Mount supports on 1/2" thick vibration isolation pads set on concrete housekeeping pads.

C. Provide engraved phenolic nameplates under the provisions of Section 26 05 53.

D. Connections: All conduit connections to the VFD shall be by flexible conduit.

E. Input, output, and control wiring shall each be run in separate conduits.

F. All interlocking required by the drive manufacturer shall be the responsibility of the Electrical Contractor.

3.3 STARTUP AND COMMISSIONING

A. Verify all settings, parameters, and adjustments with other contractors prior to startup. Make all adjustments and setting to coordinate with controls and equipment.

B. Accelerate the motor to full speed and verify operation. Decelerate the motor to a stop and verify operation. Slowly operate the motor over the speed range and check for resonance.

C. Make all adjustments and settings to coordinate with controls and equipment prior to Substantial Completion. Verify that drive is set for auto restart after power loss and undervoltage fault.

D. Document settings in the Operations and Maintenance manual.

END OF SECTION

SECTION 23 05 29
HVAC SUPPORTS AND ANCHORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Hangers, Supports, and Associated Anchors.
B. Equipment Bases and Supports.
C. Sleeves and Seals.
D. Flashing and Sealing of Equipment and Pipe Stacks.
E. Cutting of Openings.
F. Escutcheon Plates and Trim.

1.2 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 23 05 00.

1.3 WORK FURNISHED BUT INSTALLED UNDER OTHER SECTIONS

A. Furnish sleeves and hanger inserts to General Contractor for placement into formwork.

PART 2 - PRODUCTS

2.1 HANGER RODS

A. Hanger rods for single rod hangers shall conform to the following:

Pipe Size	Hanger Rod Diameter	
	Column #1	Column #2
2" and smaller	3/8"	3/8"
2-1/2" through 3-5/8”	1/2"	1/2"
4" and 5"	5/8"	1/2"
6"	3/4"	5/8"

Column #1: Steel pipe.
Column #2: Copper or plastic pipe.

B. Rods for double rod hangers may be reduced one size. Minimum rod diameter is 3/8 inches.

C. Hanger rods and accessories used in mechanical spaces or otherwise dry areas shall have ASTM B633 electro-plated zinc finish.

2.2 PIPE HANGERS AND SUPPORTS

A. All pipe hangers, clamps, and supports shall conform to Manufacturers Standardization Society MSS-SP-58 and 127 (where applicable).

B. Oversize all hangers, clamps, and supports on insulated piping to allow insulation and jacket to pass through unbroken. This applies to both hot and cold pipes.

C. Ferrous hot piping 2-1/2 inches and larger shall have steel saddles tack welded to the pipe at each support at a depth not less than the specified insulation. Factory fabricated inserts may be used.

Acceptable Products:

Anvil -	Fig. 160, 161, 162, 163, 164, 165
Cooper/B-Line -	Fig. 3160, 3161, 3162, 3163, 3164, 3165
Erico -	Model 630, 631, 632, 633, 634, 635
Nibco/Tolco -	Fig. 260-1, 261-1 1/2, 262-2, 263-2 1/2, 264-3, 265-4

D. On all insulated piping, provide a semi-cylindrical metallic shield and fire resistant vapor barrier jacket.

E. As an alternative to separate pipe insulation insert and saddle, properly sized integral rigid insulation sections may be used for this application.

Acceptable Products:

Cooper/B-Line -	Fig. B3380 through B3384
Pipe Shields -	A1000, A2000
Erico -	Model 124, 127

F. Support and laterally brace vertical pipes at every floor level in multi-story structures, and more frequently when required by applicable codes (the Illinois Plumbing Code requires 10 foot maximum spacing for support of copper risers), but never at intervals over 15 feet. Support vertical pipes with riser clamps installed below hubs, couplings or lugs. Provide sufficient flexibility to accommodate expansion and contraction without compromising fire barrier penetrations and other fixed take-off locations.

Acceptable Products:

Anvil -	Fig. CT121
Cooper/B-Line -	Fig. B3373CT
Erico -	Model 510
Nibco/Tolco -	Fig. 82

G. Place restrained neoprene mounts beneath vertical pipe riser clamps to prevent sweating of cold pipes. Insulate over mounts.

Acceptable Products: Mason RBA, RCA, or BR.

H. Hangers in direct contact with copper pipe shall be coated with plastic with appropriate temperature range. HYDRA-ZORB clamps are permitted for this application for bare pipes within their temperature limits of -65°F to +275°F.

I. Unless otherwise indicated, hangers shall be as follows:

1. Clevis Type:

Service: Bare Metal Pipe
Rigid Plastic Pipe
Insulated Cold Pipe
Insulated Hot Pipe - 3 inches & Smaller

Acceptable Products:	Bare Steel, Plastic or Insulated Pipe	Bare Copper Pipe
Anvil	Fig. 260	
Cooper/B-Line	Fig. 3100	Fig. B3100C
Erico	Model 400	
Nibco/Tolco	Fig. 1	Fig. 81PVC

2. Roller Type:
Service: Insulated Hot Pipe - 4 inches and Larger

Acceptable Products:	4" through 6"	8" and Above
Anvil	Fig. 181, 271	Fig. 171, 271
Cooper/B-Line	Fig. 3110, 3117	Fig. 3114, 3117
Erico	Model 610	Model 605
Nibco/Tolco	Fig. 324, 327	Fig. 322, 327

3. Continuous Channel with Clevis Type:
Service: Plastic Tubing
Flexible Hose
Soft Copper Tubing

Acceptable Products:
Cooper/B-Line - Fig. B3106, with Fig. B3106V
Erico - Model 104, with Model 104V
Nibco/Tolco - Fig. 1V

4. Adjustable Swivel Ring Type:
Service: Bare Metal Pipe - 4 inches and Smaller

Acceptable Products:	Bare Steel Pipe	Bare Copper Pipe
Anvil	Fig. 69	
Cooper/B-Line	Fig. B3170NF	Fig. B3170CTC
Erico	Model FCN	102A0 Series
Nibco/Tolco	Fig. 200	Fig. 203

J. Support may be fabricated from U-Channel strut or similar shapes. Piping less than 4" in diameter shall be secured to strut with clamps of proper design and capacity as required to maintain spacing and alignment. Strut shall be independently supported from hanger drops or building structure. Size and support shall be per manufacturer's installation requirements for structural support of piping. Clamps shall not interrupt piping insulation.

1. Strut used in mechanical spaces or otherwise dry areas shall have ASTM B633 electro-plated zinc finish.

2. Strut used in damp areas listed in hanger rods shall have ASTM A123 hot-dip galvanized finish applied after fabrication.

K. Unless otherwise indicated, pipe supports for use with struts shall be as follows:

1. Clamp Type:
Service: Bare Metal Pipe
Rigid Plastic Pipe
Insulated Cold Pipe
Insulated Hot Pipe - 3 inches and smaller

a. Clamps in direct contact with copper pipe shall be plastic coated.

b. Pipes subject to expansion and contraction shall have clamps slightly oversized to allow limited pipe movement.

Acceptable Products:	Bare Steel, Plastic or Insulated Pipe	Bare Copper Pipe
Unistrut	Fig. P1100 or P2500	
Cooper/B-Line	Fig. B2000 or B2400	Fig. BVT
Nibco/Tolco	Fig. A-14 or 2STR	

2. Roller Type:

Service: Insulated Hot Pipe - 4 inches and larger.

Acceptable Products:	4" through 6"	8" and Above
Unistrut	Fig. P2474	Fig. P2474-1
Cooper/B-Line	Fig. B218	Fig. B219
Nibco/Tolco	Fig. ROL-12	Fig. ROL-13

L. Unless otherwise shown, upper attachments for hanger rods or support struts shall be as follows:

1. Beam Clamps:

Acceptable Products:	
Anvil	Fig. 228, 292
Cooper/B-Line	Fig. B3054
Erico	Model 360
Nibco/Tolco	Fig. 329

2. Concrete Inserts, Single Rod Galvanized:

Acceptable Products:	
Anvil	Fig. 282
Cooper/B-Line	Fig. B3014
Erico	Model 355
Nibco/Tolco	Fig. 310

3. Concrete Inserts, Continuous Strip Galvanized:

Acceptable Products:	
Unistrut Corp	P3200 Series
Cooper/B-Line	Fig. B22-J
Erico	CONCT

4. Concrete Anchors: Fasten to concrete using cast-in or post-installed anchors designed per the requirements of Appendix D of ACI 318-14. Post-installed anchors shall be qualified for use in cracked concrete by ACI-355.2.

5. Masonry Anchors: Fasten to concrete masonry units with expansion anchors or self-tapping masonry screws. For expansion anchors into hollow concrete block, use sleeve-type anchors designed for the specific application. Do not fasten in masonry joints. Do not use powder actuated fasteners, wooden plugs, or plastic inserts.

M. Wall supports shall be used where vertical height of structure exceeds minimum spacing requirements. Install wall supports at same spacing as hangers or strut supports along vertical length of pipe runs.

N. Welding:

1. Unless otherwise noted, hangers, clips, and auxiliary support steel may be welded in lieu of bolting, clamping, or riveting to the building structural frame. Take adequate precautions during all welding operations for fire prevention and for protecting walls and ceilings from being damaged by smoke.

2.3 FOUNDATIONS, BASES, AND SUPPORTS

A. Basic Requirements:

1. Furnish and install foundations, bases, and supports (not specifically indicated on the Drawings or in the Specifications of either the General Construction or Mechanical work as provided by another Contractor) for mechanical equipment.

2. All concrete foundations, bases and supports, shall be reinforced. All steel bases and supports shall receive a prime coat of zinc chromate or red metal primer. After completion of work, give steel supports a final coat of gray enamel.

B. Concrete Bases (Housekeeping Pads):

1. Unless shown otherwise on the drawings, concrete bases shall be nominal 4 inches thick and shall extend 3 inches on all sides of the equipment (6 inches larger than factory base).

2. Where a base is less than 12 inches from a wall, extend the base to the wall to prevent a “dirt-trap”.

3. Concrete materials and workmanship required for the Contractor's work shall be provided by him. Materials and workmanship shall conform to the applicable standards of the Portland Cement Association. Reinforce with 6”x6”, W1.4-W1.4 welded wire fabric. Concrete shall withstand 3,000 pounds compression per square inch at 28 days.

4. Equipment requiring bases is as follows:

a. Air Handling Unit
b. Boiler
c. Chemical Feed Equipment
d. Expansion Tank
e. Fans
f. Pump

C. Supports:

1. Provide sufficient clips, inserts, hangers, racks, rods, and auxiliary steel to securely support all suspended material, equipment and conduit without sag.

2. Hang heavy equipment from concrete floors or ceilings with Architect/Engineer-approved concrete inserts, furnished and installed by the Contractor whose work requires them, except where indicated otherwise.

D. Grout:

1. Grout shall be non-shrinking premixed (Master Builders Company "Embecco"), unless otherwise indicated on the drawings or approved by the Architect/Engineer.

2. Use Mix No. 1 for clearances of 1" or less, and Mix No. 2 for all larger clearances.

3. Grout under equipment bases, around pipes, at pipe sleeves, etc., and where shown on the drawings.

2.4 OPENINGS IN FLOORS, WALLS AND CEILINGS

A. Exact locations of all openings for the installation of materials shall be determined by the Contractor and given to the General Contractor for installation or construction as the structure is built.

B. Coordinate all openings with other Contractors.

C. Hire the proper tradesman and furnish all labor, material and equipment to cut openings in or through existing structures, or openings in new structures that were not installed, or additional openings. Repair all spalling and damage to the satisfaction of the Architect/Engineer. Make saw cuts before breaking out concrete to ensure even and uniform opening edges.

D. Said cutting shall be at the complete expense of each Contractor. Failure to coordinate openings with other Contractors shall not exempt the Contractor from providing openings at his expense.

E. Do not cut structural members without written approval of the Architect or Structural Engineer.

2.5 ROOF PENETRATIONS

A. Seal pipes with surface temperature below 150ºF penetrating single-ply roofs with conical stepped pipe flashings and stainless steel clamps equal to Portals Plus Pipe Boots. Material shall match roofing membrane.

B. Break insulation only at the clamp for pipes between 60ºF and 150ºF. Seal outdoor insulation edges watertight.

2.6 SLEEVES AND LINTELS

A. Each Contractor shall provide sleeves and lintels for all duct and pipe openings required for the Contractor's work in masonry walls and floors, unless specifically shown as being by others.

B. Fabricate all sleeves from standard weight black steel pipe or as indicated on the drawings. Provide continuous sleeve. Cut or split sleeves are not acceptable.

C. Fabricate all lintels for masonry walls from structural steel shapes or as indicated on the drawings. Have all lintels approved by the Architect or Structural Engineer.

D. Sleeves through the floors on exposed risers shall be flush with the ceiling, with planed squared ends extending 1" above the floor in unfinished areas, and flush with the floor in finished areas, to accept spring closing floor plates.

E. Sleeves shall not penetrate structural members or masonry walls without approval from the Structural Engineer. Sleeves shall then comply with the Architect/Engineer's design.

F. Openings through unexcavated floors and/or foundation walls below the floor shall have a smooth finish with sufficient annular space around material passing through opening so slight settling will not place stress on the material or building structure.

G. Install all sleeves concentric with pipes. Secure sleeves in concrete to wood forms. This Contractor is responsible for sleeves dislodged or moved when pouring concrete.

H. Where pipes rise through concrete floors that are on earthen grade, provide 3/4" resilient expansion joint material (asphalt and cork) wrapped around the pipe, the full depth of concrete, at the point of penetration. Secure to prevent shifting during concrete placement and finishing.

I. Size sleeves large enough to allow expansion and contraction movement. Provide continuous insulation wrapping.

2.7 ESCUTCHEON PLATES AND TRIM

A. Fit escutcheons to all insulated or uninsulated exposed pipes passing through walls, floors, or ceilings of finished rooms.

B. Escutcheons shall be heavy gauge, cold rolled steel, copper coated under a chromium plated finish, heavy spring clip, rigid hinge and latch.

C. Install galvanized steel (unless otherwise indicated) trim strip to cover vacant space and raw construction edges of all rectangular openings in finished rooms. This includes pipe openings.

2.8 PIPE PENETRATIONS

A. Seal all pipe penetrations. Seal non-rated walls and floor penetrations with grout or caulk. Backing material may be used.

B. Seal fire rated wall and floor penetrations with fire seal system as specified.

2.9 PIPE ANCHORS

A. Provide all items needed to allow adequate expansion and contraction of all piping. All piping shall be supported, guided, aligned, and anchored as required.

B. Repair all piping leaks and associated damage. Pipes shall not rub on any part of the building.

2.10 FINISH

A. Prime coat exposed steel hangers and supports. Hangers and supports in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

PART 3 - EXECUTION

3.1 HVAC SUPPORTS AND ANCHORS

A. General Installation Requirements:

1. Install all items per manufacturer's instructions.

2. Coordinate the location and method of support of piping systems with all installations under other Divisions and Sections of the Specifications.

3. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

B. Supports Requirements:

1. Install roof pipe supports to resist wind movement per manufacturer’s recommendations. Method of securing base to roof shall be compatible with roofing materials.

2. Where building structural steel is fireproofed, all hangers, clamps, auxiliary steel, etc., which attach to it shall be installed prior to application of fireproofing. Repair all fireproofing damaged during pipe installation.

3. Set all concrete inserts in place before pouring concrete.

4. Furnish, install and prime all auxiliary structural steel for support of piping systems that are not shown on the Drawings as being by others.

5. Install hangers and supports complete with lock nuts, clamps, rods, bolts, couplings, swivels, inserts and required accessories.

6. Hangers for horizontal piping shall have adequate means of vertical adjustment for alignment.

C. Pipe Requirements:

1. Support all piping and equipment, including valves, strainers, traps and other specialties and accessories to avoid objectionable or excessive stress, deflection, swaying, sagging or vibration in the piping or building structure during erection, cleaning, testing and normal operation of the systems.

2. Do not, however, restrain piping to cause it to snake or buckle between supports or to prevent proper movement due to expansion and contraction.

3. Support piping at equipment and valves so they can be disconnected and removed without further supporting the piping.

4. Piping shall not introduce strains or distortion to connected equipment.

5. Parallel horizontal pipes may be supported on trapeze hangers made of structural shapes and hanger rods; otherwise, pipes shall be supported with individual hangers.

6. Trapeze hangers may be used where ducts interfere with normal pipe hanging.

7. Provide additional supports where pipe changes direction, adjacent to flanged valves and strainers, at equipment connections and heavy fittings.

8. Provide at least one hanger adjacent to each joint in grooved end steel pipe with mechanical couplings.

D. Provided the installation complies with all loading requirements of truss and joist manufacturers, the following practices are acceptable:

1. Loads of 100 lbs. or less may be attached anywhere along the top or bottom chords of trusses or joists with a minimum 3’ spacing between loads.

2. Loads greater than 100 lbs. must be hung concentrically and may be hung from top or bottom chord, provided one of the following conditions is met:

   a. The hanger is attached within 6” from a web/chord joint.

   b. Additional L2x2x1/4 web reinforcement is installed per manufacturer’s requirements.

3. It is prohibited to cantilever a load using an angle or other structural component that is attached to a truss or joist in such a fashion that a torsional force is applied to that structural member.

4. If conditions cannot be met, coordinate installation with truss or joist manufacturer and contact Architect/Engineer.

E. After piping and insulation installation are complete, cut hanger rods back at trapeze supports so they do not extend more than 3/4" below bottom face of lowest fastener and blunt any sharp edges.

F. Do not exceed 25 lbs. per hanger and a minimum spacing of 2’-0” on center when attaching to metal roof decking (limitation not required with concrete on metal deck). This 25 lbs. load and 2’-0” spacing include adjacent electrical and architectural items hanging from deck. If the hanger restrictions cannot be achieved, supplemental framing off steel framing will need to be added.

G. Do not exceed the manufacturer's recommended maximum load for any hanger or support.

H. Spacing of Hangers shall not exceed the compressive strength of the insulation inserts, and in no case shall exceed the following:

	Pipe Material	Maximum Spacing
1.	Steel and Fiberglass (Std. Weight or Heavier – Liquid Service):	
	1-1/4" & under	7'-0"
	1-1/2"	9'-0"
	2"	10'-0"
	2-1/2"	11'-0"
	3"	12'-0"
	4" & larger	12'-0"

	Pipe Material	Maximum Spacing
2.	Steel (Std. Weight or Heavier – Vapor Service):	
	1-1/4" and under	9'-0"
	1-1/2"	12'-0"
	2" & larger	12'-0"
3.	Hard Drawn Copper & Brass (Liquid Service):	
	3/4" and under	5'-0"
	1"	6'-0"
	1-1/4"	7'-0"
	1-1/2"	8'-0"
	2"	8'-0"
	2-1/2"	9'-0"
	3"	10'-0"
	4"	12'-0"
	6"	12'-0"
4.	Hard Drawn Copper & Brass (Vapor Service):	
	3/4" & under	7'-0"
	1"	8'-0"
	1-1/4"	9'-0"
	1-1/2"	10'-0"
	2"	11'-0"
	2-1/2" & larger	12'-0"

1 5. Installation of hangers shall conform to MSS SP-58 and the applicable Plumbing Code.

2 **END OF SECTION**

SECTION 23 05 48
HVAC VIBRATION ISOLATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Vibration Isolation.
B. Flexible Connectors.

1.2 SUBMITTALS

A. Submit shop drawings per Section 23 05 00 and the Vibration Isolation Submittal Form at the end of this section.

B. Vibration isolation submittals may be included with equipment being isolated, but must comply with this section.

C. Base submittals shall include equipment served, construction, coatings, weights, and dimensions.

D. Isolator submittals shall include:

1. Equipment served
2. Type of Isolator
3. Load in Pounds per Isolator
4. Recommended Maximum Load for Isolator
5. Spring Constants of Isolators (for Spring Isolators)
6. Load vs. Deflection Curves (for Neoprene Isolators)
7. Specified Deflection
8. Deflection to Solid (at least 150% of calculated deflection)
9. Loaded (Operating) Deflection
10. Free Height
11. Loaded Height
12. Kx/Ky (horizontal to vertical stiffness ratio – for spring isolators)
13. Materials and Coatings
14. Spring Diameters

E. Make separate calculations for each isolator on equipment where the load is not equally distributed.

F. Flexible connector shop drawings shall include overall face-to-face length and all specified properties.

PART 2 - PRODUCTS

2.1 BASIC CONSTRUCTION AND REQUIREMENT

A. Vibration isolators shall have either known undeflected heights or other markings so deflection under load can be verified.

B. All isolators shall operate in the linear portion of their load versus deflection curve. The linear portion of the deflection curve of all spring isolators shall extend 50% beyond the calculated operating deflection [e.g., 3" for 2" calculated deflection]. The point of 50% additional deflection shall not exceed the recommended load rating of the isolator.

C. The lateral to vertical stiffness ratio (Kx/Ky) of spring isolators shall be between 0.8 and 2.0.

D. All neoprene shall have UV resistance sufficient for 20 years of outdoor service.

E. All isolators shall be designed or treated for corrosion resistance. Steel bases shall be cleaned of welding slag and primed for interior use, and hot dip galvanized after fabrication for exterior use. All bolts and washers over 3/8" diameter located outdoors shall be hot dip galvanized per ASTM A153. All other bolts, nuts and washers shall be zinc electroplated. All ferrous portions of isolators, other than springs, for exterior use shall be hot dip galvanized after fabrication. Outdoor springs shall be neoprene dipped or hot dip galvanized. All damage to coatings shall be field repaired with two coats of zinc rich coating.

F. Equip all mountings used with structural steel bases with height-saving brackets. Bottoms of the brackets shall be 1-1/2" to 2-1/2" above the floor or housekeeping pad, unless shown otherwise on the drawings. Steel bases shall have at least four points of support.

G. Provide motor slide rails for belt-driven equipment per Section 23 05 13.

H. All isolators, except M1, shall have provision for leveling.

2.2 MOUNTINGS

A. Type M1:

1. 0.75" thick waffled neoprene pad with minimum static deflection of 0.07" at calculated load and 0.11" at maximum load. For loads less than 15 pounds, the deflection at calculated load requirement is waived, but the isolator must have a maximum stiffness of the ratio of 45#/0.35".

2. Units need not be bolted down unless called for or needed to prevent movement. If bolted down, prevent short circuiting with neoprene bushings and washers between bolts and isolators.

3. Acceptable Manufacturers: Mason "Super W", Kinetics "NGS", Amber/Booth "SPNR", Vibration Eliminator Co. "400N".

B. Type M3:

1. Free standing, laterally stable spring isolators without housings and complete with 1/4" neoprene friction pads.

2. Units shall have bolt holes but need not be bolted down unless called for or needed to prevent movement. If bolted down, prevent short circuiting with neoprene bushings and washers between bolts and isolators. Bolt holes shall not be within the springs.

3. All mountings shall have leveling bolts.

4. Acceptable Manufacturers: Mason "SLFH", Kinetics "FDS", Amber/Booth "SW-3, 4", 5"or 6", Vibration Eliminator Co. "OST".

2.3 HANGERS

A. Type H1:

1. Vibration hangers shall consist of a double-deflection neoprene element with a projecting bushing or oversized opening to prevent steel-to-steel contact.

2. Static deflection shall be at least 0.15" at calculated load and 0.35" at maximum rated load.

3. Provide hangers with end connections as required for hanging ductwork or piping.

4. Acceptable Manufacturers: Mason "HD" or "WHD", Kinetics "RH", Aeroflex "RHD", Vibration Eliminator Co. "ALH".

B. Type H2:

1. Vibration hangers shall contain a steel spring in a neoprene cup with a grommet to prevent short circuiting the hanger rod.

2. The cup shall have a steel washer to distribute load on the neoprene and prevent its extrusion.

3. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30º arc before contacting the grommet and short circuiting the spring.

4. Provide end connections for hanging ductwork or piping.

5. Acceptable Manufacturers: Mason "30" or "W30", Kinetics "SRH", Amber/Booth "BSRA", Aeroflex "RSH", Vibration Eliminator Co. "SNC".

C. Type H3:

1. Vibration hangers shall have a steel spring in a neoprene cup with a grommet to prevent short circuiting of the hanger rod.

2. The cup shall have a steel washer to distribute load on the neoprene and prevent its extrusion.

3. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30º arc before contacting the grommet and short circuiting the spring.

4. Provide end connections for hanging ductwork or piping.

5. Hangers shall be capable of holding the load at a fixed elevation during installation. They shall have a secondary adjustment to transfer the load to the spring and maintain the same position.

6. Deflection shall be indicated by a pointer and scale.

7. Acceptable Manufacturer: Mason "PC30", Kinetics "SFH", Amber/Booth "BSW", Vibration Eliminator Co. "PCS".

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. Install all products per manufacturer's recommendations.

B. Provide vibration isolation as indicated on the drawings and as described herein.

C. Clean the surface below all mountings that are not bolted down and apply adhesive cement equal to Mason Type WG between mounting and floor. If movement occurs, bolt mountings down. Isolate bolts from baseplates with neoprene washers and bushings.

D. All static deflections listed in the drawings and specifications are the minimum acceptable actual deflection of the isolator under the weight of the installed equipment - not the maximum rated deflection of the isolator.

E. Support equipment to be mounted on structural steel frames with isolators under the frames or under brackets welded to the frames. Where frames are not needed, fasten isolators directly to the equipment.

F. Where a specific quantity of hangers is noted in these specifications, it shall mean hanger pairs for support points that require multiple hangers, such as rectangular ducts or pipes supported on a strut rack.

3.2 PIPE ISOLATION

A. The first three hangers from vibration-isolated equipment shall be type H1.

B. Provide sufficient piping flexibility for vibrating refrigerant equipment, or furnish flexible connectors with appropriate temperature and pressure ratings.

C. Vibration isolators shall not cause any change in position of piping that will result in stresses in connections or misalignment of shafts or bearings. Equipment and piping shall be maintained in a rigid position during installation. Do not transfer load to the isolators until the installation is complete and under full operational load. Hanger H3 and Mounting M4 may be used instead of other products for this purpose.

D. Support piping to prevent extension of flexible connectors.

3.3 VIBRATION ISOLATION OF DUCTWORK

A. The first three hangers on all fan systems shall be Type H1 with at least 0.20" minimum static deflection.

3.4 VIBRATION ISOLATION SCHEDULE

EQUIPMENT DESIGNATION	BASE TYPE	ISOLATOR TYPE	STATIC DEFLECTION	FLEXIBLE CONNECTIONS
Inline Pump(s)	NA	M3 or H2 or H3	0.75"	NA
Boilers	NA	NA	NA	FC-1

Note 1: AHU internal fan isolation shall be determined by AHU manufacturer. Isolation selected shall be a minimum of 98% efficient at scheduled CFM and static pressure.

COLUMN 1	2	3	4	5	6	7	8	9	10	11	12
		PROPOSED ISOLATOR							CALCULATIONS		
ITEM SERVED	MIN DEFL (")	TAG	MODEL	MAX LOAD (#)	DEFL @ MAX LOAD (")	DEFL TO SOLID (")	FREE HT (")	Kx/Ky	LOAD (#)	DEFL (")	DEFL RATIO

COLUMN NOTES: Note numbers correspond to the column numbers above.

1. Item served should match designation on the design drawings.
2. List the deflection scheduled or specified in the design documents.
3. List the designation for this isolator. This is most useful when one item has multiple different isolators to support its weight.
4. List the manufacturer's complete model designation for the isolator.
5. List the manufacturer's maximum rated load for the isolator.
6. List the isolator deflection at the maximum rated load in column 5.
7. For spring isolators list the deflection when the springs are solid. This is not normally the same entry as in column 6.
8. List the height of the isolator when unloaded. Shop drawings must show where this is measured.
9. List the rated horizontal to vertical stiffness ratio. This must be between 0.8 and 2.0.
10. List the calculated equipment load on each isolator. For items with unequal weight distribution, calculate each isolator separately.
11. List the calculated deflection under the calculated load. For springs this will be column 10*(column 6 / column 5).
12. List the answer from dividing column 7 by column 11. This must be at least 1.5. If not, select an isolator with more nominal deflection.

GENERAL NOTES:

1. When submitting hangers or supports for a weight range, fill in two rows - one for the maximum and one for the minimum weight.

END OF SECTION

SECTION 23 05 53
HVAC IDENTIFICATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Identification of products installed under Division 23.

1.2 SUBMITTALS

A. Submit shop drawings under provisions of Section 23 05 00. Include list of items identified, wording, letter sizes, and color coding.

B. Include valve chart and schedule listing valve tag number, location, function, and valve manufacturer's name and model number.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. 3M, Bunting, Calpico, Craftmark, Emedco, Kolbi Industries, Seton, W.H. Brady, Marking Services.

2.2 MATERIALS

A. All pipe markers (purchased or stenciled) shall conform to ANSI A13.1. Marker lengths and letter sizes shall be at least the following:

O.D. of Pipe or insulation	Marker Length	Size of Letters
Up to and including 1-1/4”	8”	1/2”
1-1/2” to 2”	8”	3/4”
2-1/2” to 6”	12”	1-1/4”
8” to 10”	24”	2-1/2”
Over 10”	32”	3-1/2”

Plastic tags may be used for outside diameters under 3/4".

B. Plastic Nameplates: Laminated three-layer phenolic with engraved black, 1/4" minimum letters on light contrasting background.

C. Aluminum Nameplates: Black enamel background with natural aluminum border and engraved letters furnished with two mounting holes and screws.

D. Plastic Tags: Minimum 1-1/2" square or round laminated three-layer phenolic with engraved, 1/4" minimum black letters on light contrasting background.

E. Brass Tags: Brass background with engraved black letters. Tag size minimum 1-1/2" square or 1-1/2" round.

F. Plastic Pipe Markers: Semi-rigid plastic, preformed to fit around pipe or pipe covering; indicating flow direction and fluid conveyed.

G. Vinyl Pipe Markers: Colored vinyl with permanent pressure sensitive adhesive backing.

H. Stencil Painted Pipe Markers: Use industrial enamel spray paint per ANSI Standard A13.1. Indicate fluid conveyed and flow direction.

I. Underground Pipe Markers: Bright colored continuously printed plastic ribbon tape 6" wide by 3.5 mils thick, manufactured for direct burial, with aluminum foil core for location by non-ferric metal detectors and bold lettering identifying buried item.

J. Tracer Wire:

1. Single copper conductors shall be solid or stranded annealed or hard uncoated copper per UL83 and ASTM requirements. Tracer tape or copper-coated steel wire is not acceptable.

2. Conductor shall be insulated with HMWPE as specified and applied in a concentric manner. The minimum at any point shall not be less than 90% of the specified average thickness in compliance with UL 83.

3. Tracer wire shall be continuously spark tested at 7500 Volts DC. Other electrical and mechanical tests shall be in accordance with UL 1581.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all products per manufacturer's recommendations.

B. Degrease and clean surfaces to receive adhesive for identification materials.

C. Valves:

1. All valves (except shutoff valves at equipment) shall have numbered tags.

2. Provide or replace numbered tags on all existing valves that are connected to new systems or that have been revised.

3. Provide all existing valves used to extend utilities to this project with numbered tags. Review tag numbering sequence with the Owner prior to ordering tags.

4. Secure tags with heavy duty key chain and brass "S" link or with mechanically fastened plastic straps.

5. Attach to handwheel or around valve stem. On lever operated valves, drill the lever to attach tags.

6. Number all tags and show the service of the pipe.

7. Provide two sets of laminated 8-1/2" x 11" copies of a valve directory listing all valves, with respective tag numbers, uses, and locations. The directory shall be reviewed by the Owner and Architect/Engineer prior to laminating final copies. Laminated copies shall have brass eyelet in at least one corner for easy hanging.

D. Pipe Markers:

1. Adhesive Backed Markers: Use Brady Style 1, 2, or 3 on pipes 3" diameter and larger. Use Brady Style 4, 6, or 8 on pipes under 3" diameter. Similar styles by other listed manufacturers are acceptable. Secure all markers at both ends with a wrap of pressure sensitive tape completely around the pipe.

2. Snap-on Markers: Use Seton "Setmark" on pipes up to 5-7/8" OD. Use Seton "Setmark" with nylon or Velcro ties for pipes 6" OD and over. Similar styles by other listed manufacturers are acceptable.

3. Stencil Painted Pipe Markers:

   a. Remove rust, grease, dirt, and all foreign substances from the pipe surface.
   b. Apply primer on non-insulated pipes before painting.
   c. Use background and letter colors as scheduled later in this section.

4. Apply markers and arrows in the following locations where clearly visible:

   a. At each valve.
   b. On both sides of walls that pipes penetrate.
   c. At least every 20 feet along all pipes.
   d. On each riser and each leg of each "T" joint.
   e. At least once in every room and each story traversed.

5. Underground Pipe Markers: Install 8" to 10" below grade, directly above buried pipes.

E. Equipment:

1. All equipment not easily identifiable such as controls, relays, gauges, etc.; and all equipment in an area remote from its function such as air handling units, exhaust fans, filters, reheat coils, dampers, etc.; shall have nameplates or plastic tags listing name, function, and drawing symbol. Do not label exposed equipment in public areas.

2. Fasten nameplates or plastic tags with stainless steel self-tapping screws or permanently bonding cement.

3. Mechanical equipment that is not covered by the U.S. National Appliance Energy Conservation Act (NAECA) of 1987 shall carry a permanent label installed by the manufacturer stating that the equipment complies with the requirements of ASHRAE 90.1.

F. Miscellaneous:

1. Attach self-adhesive vinyl labels at all duct access doors used to reset fusible links or actuators on fire, fire/smoke, or smoke dampers. Lettering shall be a minimum of 1/2" high. Labels shall indicate damper type.

2. Provide engraved plastic tags at all hydronic or steam system make-up water meters.

3.2 SCHEDULE

A. Pipes to be marked shall be labeled with the text as shown in the following table regardless of which method or material is used:

Pipe Service	Lettering Color	Background Color
HEATING WATER SUPPLY	Black	Yellow
HEATING WATER RETURN	Black	Yellow
GEOTHERMAL WATER SUPPLY	White	Green
GEOTHERMAL WATER RETURN	White	Green
CONDENSATE DRAIN	Black	Yellow

END OF SECTION

SECTION 23 05 93
TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Testing, adjusting, and balancing of air systems.
B. Testing, adjusting, and balancing of heating systems.
C. Testing, adjusting, and balancing of plumbing systems.
D. Testing, adjusting, and balancing of energy recovery systems.
E. Measurement of final operating condition of HVAC systems.

1.2 QUALITY ASSURANCE

A. Agency shall be a company specializing in the adjusting and balancing of systems specified in this section with minimum three years' experience. Perform work under supervision of AABC Certified Test and Balance Engineer, NEBB Certified Testing, Balancing and Adjusting Supervisor, SMARTA Certified Air and Hydronic Balancer, or TABB Certified Supervisor.

B. Work shall be performed in accordance with the requirements of the references listed at the start of this section.

1.3 REFERENCES

A. AABC - National Standards for Total System Balance, 2002.

B. ADC – Test Code for Grilles, Registers, and Diffusers.

C. AMCA – Publication 203-90; Field Performance Measurement of Fan Systems.

D. ASHRAE - 2003 HVAC Applications Handbook; Chapter 37, Testing, Adjusting and Balancing.

E. ASHRAE/ANSI - Standard 111-1988; Practices for Measurement, Testing, Adjusting and Balancing of Building HVAC&R Systems.

F. NEBB - Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems, Sixth Edition, 1998.

G. SMACNA - HVAC Systems; Testing, Adjusting and Balancing, Third Edition, 2002.

H. TABB – International Standards for Environmental Systems Balance.

1.4 SUBMITTALS

A. Submit copies of report forms, balancing procedures, and the name and qualifications of testing and balancing agency for approval within 30 days after award of Contract.

B. Submit certified copies of test reports to the Architect/Engineer for approval.

1.5 REPORT FORMS

A. Submit reports on AABC, SMACNA or NEBB forms. Use custom forms approved by the Architect/Engineer when needed to supply specified information.

B. Include in the final report a schematic drawing showing each system component, including balancing devices, for each system. Each drawing shall be included with the test reports required for that system. The schematic drawings shall identify all testing points and cross-reference these points to the report forms and procedures.

C. Refer to PART 4 for required reports.

1.6 WARRANTY/GUARANTEE

A. The TAB Contractor shall include an extended warranty of 90 days after owner receipt of a completed balancing report, during which time the Owner may request a recheck of terminals, or resetting of any outlet, coil, or device listed in the test report. This warranty shall provide a minimum of 24 man-hours of onsite service time. If it is determined that the new test results are not within the design criteria, the balancer shall rebalance the system according to design criteria.

B. Warranty/Guarantee must meet one of the following programs: TABB International Quality Assurance Program, AABC National Project Performance Guarantee, NEBB's Conformance Certification.

1.7 SCHEDULING

A. Coordinate schedule with other trades. Provide a minimum of seven days' notice to all trades and the Architect/Engineer prior to performing each test.

PART 2 - PRODUCTS

NOT APPLICABLE

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. All procedures must conform to a published standard listed in the References article of this section. All equipment shall be adjusted in accordance with the manufacturer's recommendations. Any system not listed in this specification but installed under the contract documents shall be balanced using a procedure from a published standard listed in the References article.

B. Recorded data shall represent actual measured or observed conditions.

C. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing is complete, close probe holes and patch insulation with new materials as specified. Restore vapor barrier and finish as specified.

D. Permanently mark setting of valves, dampers, and other adjustment devices allowing for settings to be restored. Set and lock memory stops.

E. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, plugging test holes, and restoring thermostats to specified settings.

F. The Balancing Contractor shall measure terminal air box air flow, and the TCC shall adjust DDC readout to match. Refer to Section 23 09 00 for additional information.

G. Installations with systems consisting of multiple components shall be balanced with all system components operating.

3.2 EXAMINATION

A. Before beginning work, verify that systems are complete and operable. Ensure the following:

1. General Equipment Requirements:

   a. Equipment is safe to operate and in normal condition.
   b. Equipment with moving parts is properly lubricated.
   c. Temperature control systems are complete and operable.
   d. Proper thermal overload protection is in place for electrical equipment.
   e. Direction of rotation of all fans and pumps is correct.
   f. Access doors are closed and end caps are in place.

2. Duct System Requirements:

   a. All filters are clean and in place. If required, install temporary media.
   b. Duct systems are clean and free of debris.
   c. Fire/smoke and manual volume dampers are in place, functional and open.
   d. Air outlets are installed and connected.
   e. Duct system leakage has been minimized.

3. Pipe System Requirements:

   a. Coil fins have been cleaned and combed.
   b. Hydronic systems have been cleaned, filled, and vented.
   c. Strainer screens are clean and in place.
   d. Shutoff, throttling and balancing valves are open.

B. Report any defects or deficiencies to Architect/Engineer.

C. Promptly report items that are abnormal or prevent proper balancing.

D. If, for design reasons, system cannot be properly balanced, report as soon as observed.

E. Beginning of work means acceptance of existing conditions.

3.3 PREPARATION

A. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to the Architect/Engineer for spot checks during testing.

B. Instruments shall be calibrated within six months of testing performed for project, or more recently if recommended by the instrument manufacturer.

3.4 INSTALLATION TOLERANCES

A. ± 10% of scheduled values:

1. Adjust air inlets and outlets to ± 10% of scheduled values.

2. Adjust piping systems to ± 10% of design values.

B. + 5% of scheduled values

1. Adjust outdoor air intakes to within + 5% of scheduled values.

2. Adjust exhaust air through energy recovery equipment to within +5% of scheduled values.

C. Adjust supply, return, and exhaust air-handling systems to +10% / -5% of scheduled values.

3.5 ADJUSTING

A. After adjustment, take measurements to verify balance has not been disrupted or that disruption has been rectified.

B. Once balancing of systems is complete, at least one damper or valve must be 100% open.

C. After testing, adjusting and balancing are complete, operate each system and randomly check measurements to verify system is operating as reported in the report. Document any discrepancies.

D. Contractor responsible for each motor shall also be responsible for replacement sheaves. Coordinate with contractor.

E. Contractor responsible for pump shall trim impeller or order new impeller to final duty point as instructed by this contractor on all pumps not driven by a VFD. Coordinate with contractor.

3.6 SUBMISSION OF REPORTS

A. Fill in test results on appropriate forms.

PART 4 - SYSTEMS TO BE TESTED, ADJUSTED AND BALANCED

4.1 GENERAL REQUIREMENTS

A. Title Page:

1. Project name.
2. Project location.
3. Project Architect.
4. Project Engineer (KJWW Engineering Consultants).
5. Project General Contractor.
6. TAB Company name, address, phone number.
7. TAB Supervisor's name and certification number.
8. TAB Supervisor's signature and date.
9. Report date.

B. Report Index

C. General Information:

1. Test conditions.
2. Nomenclature used throughout report.
3. Notable system characteristics/discrepancies from design.
4. Test standards followed.
5. Any deficiencies noted.
6. Quality assurance statement.

D. Instrument List:

1. Instrument.
2. Manufacturer, model, and serial number.
3. Range.
4. Calibration date.

4.2 AIR SYSTEMS

A. Air Moving Equipment:

1. General Requirements:
   a. Drawing symbol.
   b. Location.
   c. Manufacturer, model, arrangement, class, discharge.
   d. Fan RPM.
   e. Multiple RPM fan curve with operating point marked. (Obtain from equipment supplier).
   f. Final frequency of motor at maximum flow rate (on fans driven by VFD).
2. Flow Rate:
   a. Supply flow rate (cfm): specified and actual.
   b. Return flow rate (cfm): specified and actual.
   c. Outside flow rate (cfm): specified and actual.
   d. Exhaust flow rate (cfm): specified and actual.
3. Pressure Drop and Pressure:
   a. Filter pressure drop: specified and actual.
   b. Total static pressure: specified and actual. (Indicate if across fan or external to unit).
   c. Inlet pressure.
   d. Discharge pressure.

B. Fan Data:

1. Drawing symbol.
2. Location.
3. Manufacturer and model.
4. Flow rate (cfm): specified and actual.
5. Total static pressure: specified and actual. (Indicate measurement locations).
6. Inlet pressure.
7. Discharge pressure.
8. Fan RPM.

C. Electric Motors:

1. Drawing symbol of equipment served.
2. Manufacturer, Model, Frame.
3. Nameplate: HP, phase, service factor, RPM, operating amps, efficiency.
4. Measured: Amps in each phase.

D. Air Terminal (Inlet or Outlet):

1. Drawing symbol.
2. Room number/location.
3. Terminal type and size.
4. Velocity: specified and actual.
5. Flow rate (cfm): specified and actual.
6. Percent of design flow rate.

E. Air Terminal Unit (Terminal Air Box) Data:

1. General Requirements:
   a. Drawing symbol.
   b. Location.
   c. Manufacturer and model.
   d. Size.
   e. Type: constant, variable, single, dual duct.

2. Flow Rate:
   a. Cooling maximum flow rate (cfm): specified and actual.
   b. Minimum flow rate (cfm): specified and actual.
3. Pressure Drop and Pressure:
   a. Inlet static pressure during testing (maximum and minimum).

F. Air Flow Measuring Station:

1. Drawing symbol.
2. Service.
3. Location.
4. Manufacturer and model.
5. Size.
6. Flow rate (cfm): specified and actual.
7. Pressure drop: specified and actual.

4.3 HEATING SYSTEMS

A. Pump Data (Heating water Loop Pumps):

1. Existing drawing symbol or equipment TAG
2. Service.
3. Manufacturer, size, and model.
4. Impeller size: specified, actual, and final (if trimmed).
5. Flow Rate (gpm): specified and actual.
6. Pump Head: specified, operating and shutoff.
7. Suction Pressure: Operating and shutoff.
8. Discharge Pressure: Operating and shutoff.
9. Final frequency of motor at maximum flow rate (on pumps driven by VFD).

B. Electric Motors (Associated Heating Water Loop Pump Motors):

1. Drawing symbol of equipment served.
2. Manufacturer, Model, Frame.
3. Nameplate: HP, phase, service factor, RPM, operating amps, efficiency.
4. Measured: Amps in each phase.

C. Heating Coils:

1. General Requirements:
   a. Drawing symbol.
   b. Service.
   c. Location.
   d. Manufacturer and model.
   e. Size.
2. Flow Rate:
   a. Flow rate (cfm): specified and actual.
   b. Water flow rate: specified and actual.
3. Temperature:
   a. Entering air temperature: specified and actual.
   b. Leaving air temperature: specified and actual.
   c. Entering water temperature: specified and actual.
   d. Leaving water temperature: specified and actual.
4. Pressure Drop and Pressure:
   a. Air pressure drop: specified and actual.
   b. Steam pressure after valve: specified and actual.
   c. Water pressure drop: specified and actual.

D. Terminal Heat Transfer Units:

1. General Requirement:
   a. Drawing symbol.
   b. Location.
   c. Manufacturer and model.
   d. Include air data only for forced air units.
2. Flow Rate:
   a. Flow rate (cfm): specified and actual.
   b. Water flow rate (gpm): specified and actual.

E. Hot Water Boiler:

1. General Requirements:
   a. Drawing symbol.
   b. Service.
   c. Location.
   d. Manufacturer, model, and identification number.
   e. Control setting: specified and actual.
2. Temperature:
   a. Entering water temperature: specified and actual.
   b. Leaving water temperature: specified and actual.
3. Flow Rate:
   a. Flow rate (gpm): specified and actual.
4. Pressure Drop and Pressure:
   a. Pressure Drop: specified and actual.

4.4 PLUMBING SYSTEMS

A. Pump Data:

1. Drawing symbol.
2. Service.
3. Manufacturer, size, and model.
4. Impeller size: specified, actual, and final (if trimmed).
5. Flow Rate (gpm): specified and actual.
6. Pump Head: specified, operating and shutoff.

B. Balancing Valve:

1. Drawing symbol.
2. Service.
3. Location.
4. Size.
5. Manufacturer and model.
6. Flow rate (gpm): specified and actual.
7. Pressure drop: specified and actual.

C. Gas Fired Water Heater:

1. Drawing symbol.
2. Service.
3. Location.
4. Manufacturer and model.
5. Capacity (Btuh): specified, nameplate, and actual.
6. Entering water temperature: specified and actual.
7. Leaving water temperature: specified and actual.
8. Pressure Drop: specified and actual.

9. Control Setting: specified and actual.

4.5 ENERGY RECOVERY SYSTEMS

A. Air Systems - Air energy recovery devices shall be tested at ambient temperatures of less than 40˚F or greater than 85˚F.

1. Energy Recovery Wheel:

a. General Requirements:
   1) Drawing Symbol.
   2) Location.
   3) Wheel RPM.

b. Primary Air:
   1) Primary Entering Air Temperature.
   2) Primary Leaving Air Temperature.
   3) Primary Air Pressure Drop.
   4) Primary Air Flow Rate (cfm).

c. Secondary Air:
   1) Secondary Entering Air Temperature.
   2) Secondary Leaving Air Temperature.
   3) Secondary Air Pressure Drop.
   4) Secondary Air Flow Rate (cfm).

END OF SECTION

SECTION 23 07 13
DUCTWORK INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Ductwork Insulation.
B. Insulation Jackets.

1.2 QUALITY ASSURANCE

A. Applicator: Company specializing in ductwork insulation application with five years minimum experience. When requested, installer shall submit manufacturer's certificate indicating qualifications.

B. Materials: UL listed in Category HNKT; flame spread/smoke developed rating of 25/50 in accordance with ASTM E84, NFPA 255, or UL 723.

C. Adhesives: UL listed, meeting NFPA 90A/90B requirements.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Type A: Flexible Fiberglass - Outside Wrap; ANSI/ASTM C553; commercial grade; 0.28 maximum 'K' value at 75°F; foil scrim kraft facing, 1.0 lb./cu. ft. density.

B. Type B: Semi-rigid Fiberglass Board Wrap - Outside Application; ANSI/ASTM C612, Class 1; 0.25 maximum 'K' value at 75°F; foil scrim kraft facing, 3 lb./cu. ft. density.

C. Type C: Flexible Fiberglass Liner; ANSI/ASTM C1071; 0.28 maximum 'K' value at 75°F; 1.5 lb/cu ft minimum density; coated air side for 4000 fpm air velocity.

D. Type F: Flexible High Temperature Wrap; ASTM E2336 rating as 2-hour separation with zero clearance to combustible materials over the full length. Material to be totally scrim encapsulated. Material to be a minimum 1-1/2" thick with a minimum core density of 6 pcf. Wrap system should offer zero clearance to combustibles per ASTM E2336 at all locations, comply with all applicable codes, and be approved by AHJ. If system is not rated for zero clearance per ASTM E2336 at all locations with single layer, a two layer system shall be provided with zero clearance per ASTM E2336 at all locations. Material must be tested and listed for installation on grease ducts and installed per listed design. Refer to Section 23 33 00 for prefabricated, pre-insulated access doors required for grease duct systems.

2.2 JACKETS

A. Vapor Barrier Jackets: Kraft reinforced foil scrim vapor barrier with self-sealing adhesive joints. Beach puncture resistance ratio of at least 25 units. Tensile strength: 35 psi minimum. Single, self-seal acrylic adhesive on longitudinal jacket laps and butt strips.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install materials in accordance with manufacturer's instructions, codes, and industry standards.

B. Install materials after ductwork has been tested.

C. Clean surfaces for adhesives.

D. Provide insulation with vapor barrier when air conveyed may be below ambient temperature.

E. Exterior Duct Wrap - Flexible, Type A:

1. Apply with edges tightly butted.

2. Cut slightly longer than perimeter of duct to insure full thickness at corners. Do not wrap excessively tight.

3. Seal joints with adhesive backed tape.

4. Apply so insulation conforms uniformly and firmly to duct.

5. Provide high-density insulation inserts at trapeze duct hangers and straps to prevent crushing of insulation. Maintain continuous vapor barrier through the hanger.

6. Tape all joints with Royal Tapes #RT 350 (216-439-7229), Venture Tape 1525CW, or Compac Type FSK. No substitutions will be accepted without written permission from the Architect/Engineer.

7. Press tape tightly to the duct covering with a squeegee for a tight continuous seal. Fish mouths and loose tape edges are not acceptable.

8. Staples may be used, but must be covered with tape.

9. Vapor barrier must be continuous.

10. Mechanically fasten on 12" centers at bottom of ducts over 24" wide and on all sides of vertical ducts.

F. Semi Rigid Fiberglass Board Wrap - Type B (Indoor Use):

1. Impale on pins welded to the duct and secured with speed clips. Clip pins off close to speed clips.

2. Space pins as needed to hold insulation firmly against duct, but not less than one pin per square foot. Pins must be long enough to avoid compressing the insulation.

3. Seal all joints and speed clips with glass fabric set in adhesive or a 3" wide strip of Royal Tapes #RT 350 (216-439-7229), Venture Tape 1525CW, or Compac Type FSK facing tape.

4. For small areas, secure insulation with adhesive over the entire surface of the duct. Use adhesive in addition to pins as needed to prevent sagging on horizontal surfaces.

G. Interior Insulation - Flexible Duct Liner, Type C:

1. Observation of Duct Lining:

a. After installation of ductwork, Architect/Engineer may select random observation points in each system.

1) At each observation point, cut and remove an 18" x 18" section of ductwork and liner for verification of installation.

2) Random observation points based on one opening per 75 lineal ft. of total duct run.

b. When any of the observation points shows non-compliance, additional points will be designated by the Architect/Engineer, and observation repeated.

c. If 20% of points observed do not comply, remove and replace all lined ducts and repeat tests. Where replacement is not required, correct all non-compliances.

d. At end of observation, repair all duct lining and observation holes by installing standard, insulated, hinged access doors per Section 23 33 00.

e. Paint or finish to match adjacent duct surfaces.

2. Impale on spindle anchors welded or mechanically fastened to the duct. Adhesive or glue fastened anchors are not acceptable. Maximum anchor spacing per SMACNA Duct Construction Standards or manufacturer's recommendations, whichever is more restrictive. Locate pins less than 3" from corners and at intervals not over 6" around the perimeter at leading and trailing edges. Locate pins within 3" of transverse joints and at intervals not over 16" long the length of the duct. Pins must be long enough to prevent compressing the insulation.

3. In addition to anchors, secure liner with UL listed adhesive covering over 90% of the duct surface.

4. Install per the latest edition of the SMACNA Manual.

5. Leading edges shall be covered as follows:

a. For duct velocities below 3000 fpm, coat leading edges with adhesive. Neatly butt liner without gaps at transverse joints. Cut liner flush with end of the duct section for tight joints with no exposed duct. If adhesive is shop installed, field apply additional adhesive to the end of each duct section for complete adhesion of the liner. Protect edges from dirt and debris.

b. For duct velocities above 3000 fpm, cover leading edges with metal nosing. Use nosing on upstream edges of each section of duct. If the duct can be installed in either direction, provide nosing on each end or clearly mark the duct to allow visual verification after installation. Verify duct velocities based on the scheduled air flow rates and determine where metal nosing is required.

c. Install metal nosing in the following locations (regardless of velocity):

1) The first three fittings downstream of all fans.
2) At all duct liner interruptions. This includes fire dampers, access doors, branch connections, and all other locations where the edge of the liner is exposed.
3) Trailing edges of transverse joints do not require metal nosings.

6. Overlap liner at longitudinal joints. Make longitudinal joints at corners of the duct unless the duct size does not allow this. Coat longitudinal joints with adhesive at velocities over 2500 fpm.

7. Seal all damaged duct liner with adhesive and glass cloth. Do not damage duct liner surface coatings.

8. Duct dimensions given are net inside dimensions. Increase sheet metal to allow for insulation thickness.

H. Exterior Fire Protection, Flexible Type - Type F:

1. Cut and secure duct wrap around ductwork, support angles, and hangers per manufacturer’s recommendations.

2. Seal all joints as required to maintain enclosure rating.

3. Installation shall be rated for 2 hours, unless otherwise noted.

4. Provide manufacturer's recommended assembly to protect all access doors to maintain enclosure rating and to permit easy replacement of insulation.

I. Continue insulation with vapor barrier through penetrations unless code prohibits.

J. Provide 2" wide, 24" high, 26 gauge, galvanized sheet metal corner protection angles for all externally insulated ductwork extending to a floor or curb.

3.2 SCHEDULE

A. Refer to Section 23 31 00 for scheduling of insulation.

END OF SECTION

SECTION 23 07 16
HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Equipment Insulation.
B. Equipment Insulation Finishes.

1.2 QUALITY ASSURANCE

A. Applicator: Company specializing in insulation application with five years minimum experience.

B. Materials: Flame spread/smoke developed rating of 25/50 in accordance with ASTM E84, NFPA 255, or UL 723 (where required).

C. In accordance with LEED EQc4.1, Low-Emitting Materials - Adhesives and Sealants, all adhesives and sealants used on the interior of the building must comply with the following requirements:

1. Adhesives, sealants and sealant primers must comply with South Coast Air Quality Management District (SCAQMD) Rule #1168.

2. Aerosol adhesives must comply with Green Seal Standard for Commercial Adhesives GS-36 requirements in effect on October 19, 2000.

PART 2 - PRODUCTS

2.1 INSULATION

A. Type E: Cellular Flexible Elastomeric Foam Sheet; ANSI/ASTM C534; 0.28 maximum 'K' value at 75ºF; 25/50 flame spread/smoke developed when tested in accordance with ASTM E84 (UL 723).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all materials per manufacturer's instructions, codes and industry standards.

B. Maintain ambient temperatures and conditions required by manufacturers of adhesive and insulation.

C. Do not insulate factory insulated equipment.

D. Apply insulation as close as possible to equipment by grooving, scoring, and bevelling insulation. Secure to equipment with studs, pins, clips, adhesive, wires, or bands.

E. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor barrier mastic.

F. Do not insulate over nameplates or ASME stamps. Bevel and seal insulation around such, unless omitting insulation would cause condensation problem. When such is the case, appropriate tagging shall be provided to identify the presence of these items.

G. When equipment with insulation requires periodic opening for maintenance, repair, or cleaning; install specially fabricated removable insulation sections. Covers shall have mechanical fasteners and be reusable.

H. Install 26 gauge galvanized sheet metal corner protection angles where insulation extends to the floor. Minimum 2" coverage of insulation.

I. Insulate all equipment surfaces that are not factory insulated and are intended to operate below 60°F and/or above 100°F. Verify insulation type and thickness with equipment manufacturer and Architect/Engineer.

J. Insulate all supports on equipment operating below ambient temperature.

3.2 INSULATION

A. Type E:

1. Apply with edges tightly butted and joints staggered. Install multiple layers if required thickness is greater than 1" thick.

2. Do not wrap sheet insulation around square corners, but cut and overlap insulation at corners to provide full insulation thickness on all sides. Seal all overlapping insulation surfaces with manufacturer approved adhesive.

3. Secure with manufacturer approved adhesive in accordance with installation instructions. Where applied to underside surfaces or on surfaces with temperatures 140°F and above, cover all surfaces with full application of adhesive. Seal all joints and seams with manufacturer approved adhesive.

3.3 SCHEDULE

Equipment		Insulation Type	Insulation Thickness	Insulation Finish
A.	Geothermal Water Air Separator/Coalescing Filter	E	1"	None
B.	Geothermal Water Pumps	E	1"	None

END OF SECTION

SECTION 23 07 19
HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Piping Insulation.
B. Insulation Jackets.

1.2 QUALITY ASSURANCE

A. Applicator: Company specializing in piping insulation application with five years minimum experience.

B. Materials: Flame spread/smoke developed rating of 25/50 in accordance with ASTM E84, NFPA 255, or UL 723 (where required).

C. In accordance with LEED EQc4.1, Low-Emitting Materials - Adhesives and Sealants, all adhesives and sealants used on the interior of the building must comply with the following requirements:

1. Adhesives, sealants and sealant primers must comply with South Coast Air Quality Management District (SCAQMD) Rule #1168.

2. Aerosol adhesives must comply with Green Seal Standard for Commercial Adhesives GS-36 requirements in effect on October 19, 2000.

PART 2 - PRODUCTS

2.1 INSULATION

A. Type A: Glass fiber; ANSI/ASTM C547; 0.24 maximum 'K' value at 75ºF; non-combustible. All purpose, white kraft jacket bonded to aluminum foil and reinforced with fiberglass yarn, 25/50 flame spread/smoke developed rating when tested in accordance with ASTM E84 (UL 723).

B. Type B: Elastomeric cellular foam; ANSI/ASTM C534; flexible plastic; 0.27 maximum 'K' value at 75ºF, 25/50 flame spread/smoke developed rating when tested in accordance with ASTM E84 (UL 723). Maximum 1" thick per layer where multiple layers are specified.

C. Type C: Molded rigid cellular glass; ANSI/ASTM C-552; 0.35 maximum 'K' value at 75ºF; moisture resistant, non-combustible; suitable for -100ºF to +900ºF. For below grade installations use asphaltic mastic paper vapor barrier jacket. Use self-seal all-purpose white kraft jacket for above grade installations.

2.2 VAPOR BARRIER JACKETS

A. Kraft reinforced foil vapor barrier with self-sealing adhesive joints. Beach puncture resistance ratio of at least 50 units. Tensile strength: 35 psi minimum. Single, self-seal acrylic adhesive on longitudinal jacket laps and butt strips.

B. Polyvinylidene Chloride (PVDC or Saran) film and tape: Durable and highly moisture and moisture vapor resistant. Please refer to manufacturer's recommended installation guidelines.

2.3 REMOVABLE INSULATION JACKETS

A. Removable insulation jackets shall consist of outer covering, interstitial insulation material, and inner covering.

B. Inner and outer covering shall be constructed from a minimum 16.5 oz/yd^2 PTFE fiberglass composite and suitable for insulating surface temperatures up to 550ºF.

C. Interstitial insulation blanket shall be minimum 1-1/2" thick and shall consist of either:

1. Silica and glass-fiber insulation felts and blankets – minimum 6 lb/ft^3 density.
2. E-type glass-fiber felts and blankets – minimum 6 lb/ft^3 density.

D. Construction: Inner and outer covering with interstitial insulation material shall be joined into a single assembly using a double sewn lock stitch with 4-6 stitches/inch. The thread used shall be able to withstand minimum 550ºF surface temperatures without degradation. The use of hog rings, staples, and wires for closure of assembly are not acceptable. The interstitial insulation shall be sewn as an integral part of the inner and outer coverings to prevent shifting of the insulation. Insulation pins are not an allowable method of preventing the insulation from shifting and shall not be used.

E. No raw cut jacket edges shall be exposed.

F. Jackets shall be fastened to equipment and piping components using hook and loop (Velcro) straps and minimum 1" slide buckles.

G. Jacket coverings shall have an inner covering edge with a continuous strip of hook & loop closure (Velcro) that is parallel to the seam and overlaps the outer covering by a minimum of 2 inches.

H. Acceptable Manufacturers: Firwin Corp, Lewco Specialty Products, ThermaXX Jackets LLC or approved equivalent.

2.4 REFRIGERANT PIPE COUPLING

A. Insulation Coupling: Molded thermoplastic ASTM D1525, -65ºF to 275ºF, sizes up to 4-1/8" O.D., and receive insulation thickness up to 1". Suitable for use indoors or outdoors with UV stabilizers.

B. Acceptable Manufacturers: Klo-Shure or equal.

PART 3 - EXECUTION

3.1 PREPARATION

A. Install insulation after piping has been tested. Pipe shall be clean, dry and free of rust before applying insulation.

3.2 INSTALLATION

A. General Installation Requirements:

1. Install materials per manufacturer's instructions, building codes and industry standards.

2. Continue insulation with vapor barrier through penetrations. This applies to all insulated piping. Maintain fire rating of all penetrations.

3. On all insulated piping, provide at each support an insert of same thickness and contour as adjoining insulation, between the pipe and insulation jacket, to prevent insulation from sagging and crushing. The insert shall be suitable for planned temperatures, be suitable for use with specific pipe material, and shall be a 180° cylindrical segment the same length as metal shields. Inserts shall be a cellular glass (for all temperature ranges) or molded hydrous calcium silicate (for pipe with operating temperatures above 70°F, with a minimum compressive strength of 50 psi. Factory fabricated inserts may be used. Rectangular blocks, plugs, or wood material are not acceptable. Temporary wood blocking may be used by the Piping Contractor for proper height; however, these must be removed and replaced with proper inserts by the Insulation Contractor.

4. Neatly finish insulation at supports, protrusions, and interruptions.

5. Install metal shields between all hangers or supports and the pipe insulation. Shields shall be galvanized sheet metal, half-round with flared edges. Adhere shields to insulation. On cold piping, seal the shields vapor-tight to the insulation as required to maintain the vapor barrier, or add separate vapor barrier jacket.

6. Shields shall be at least the following lengths and gauges:

	Pipe Size	Shield Size
a.	1/2" to 3”	12" long x 18 gauge
b.	4"	12" long x 16 gauge
c.	5” to 6"	18" long x 16 gauge
d.	8” to 14"	24" long x 14 gauge
e.	16” to 24"	24" long x 12 gauge

7. All piping and insulation that does not meet 25/50 that is located in an air plenum shall have written approval from the Authority Having Jurisdiction and the local fire department for authorization and materials approval. If approval has been allowed, the non-rated material shall be wrapped with a product that has passed ASTM E84 and/or NFPA 255 testing with a rating of 25/50 or below.

B. Insulated Piping Operating Below 60°F:

1. Insulate fittings, valves, unions, flanges, strainers, flexible connections, flexible hoses, and expansion joints. Seal all penetrations of vapor barrier.

2. On piping operating below 60ºF in locations that are not mechanically cooled (e.g., penthouses, mechanical rooms, tunnels, chases at exterior walls, etc.), Type B insulation shall be used.

3. All balance valves with fluid operating below 60°F shall be insulated with a removable plug wrapped with vapor barrier tape to allow reading and adjusting of the valve.

C. Insulated Piping Operating Between 60°F and 140°F:

1. Do not insulate flanges and unions, but bevel and seal ends of insulation at such locations. Insulate all fittings, valves and strainers.

D. Insulated Piping Operating Above 140°F:

1. Insulate fittings, valves, flanges, float & thermostatic steam traps, and strainers. On gate valves, the insulation shall be extended to cover the entire valve bonnet, leaving only the portion of the stem that is above the bonnet and valve operator exposed.

2. All balance valves with fluid operating above 140°F shall be insulated and an opening shall be left in the insulation to allow for reading and adjusting the valve.

3. The use of removable insulation jackets is acceptable for insulating large and non-cylindrical shaped piping components (e.g., check valves, pressure regulating valves, calibrated balance valves, gate valve bonnets, F&T traps, strainers, line sets, and the like).

E. Exposed Piping:

1. Locate and cover seams in least visible locations.

2. Where exposed insulated piping extends above the floor, provide a sheet metal guard around the insulation extending 12" above the floor. Guard shall be 0.016" cylindrical smooth or stucco aluminum and shall fit tightly to the insulation.

3.3 INSULATION

A. Type A Insulation:

1. All Service Jackets: Seal all longitudinal joints with self-seal laps using a single pressure sensitive adhesive system. Do not staple.

2. Insulation without self-seal lap may be used if installed with Benjamin Foster 85-20 or equivalent Chicago Mastic, 3M or Childers lap adhesive.

3. Apply insulation with laps on top of pipe.

4. Fittings, Valve Bodies and Flanges: For 4" and smaller pipes, insulate with 1 lb. density insulation wrapped under compression to a thickness equal to the adjacent pipe insulation. For pipes over 4", use mitered segments of pipe insulation. Finish with preformed plastic fitting covers. Secure fitting covers with pressure sensitive tape at each end. Overlap tape at least 2" on itself. For pipes operating below 60ºF, seal fitting covers with vapor retarder mastic in addition to tape.

B. Type B Insulation:

1. Elastomeric Cellular Foam: Where possible, slip insulation over the open end of pipe without slitting. Seal all butt ends, longitudinal seams, and fittings with adhesive. At elbows and tees, use mitered connections. Do not compress or crush insulation at cemented joints. Joints shall be sealed completely and not pucker or wrinkle. Paint the outside of outdoor insulation with two coats of latex enamel paint recommended by the manufacturer.

2. Self-seal insulation may be used on pipes operating below 170ºF.

3.4 JACKET COVER INSTALLATION

A. Plastic Covering:

1. Provide vapor barrier as specified for insulation type. Cover with plastic jacket covering. Position seams to shed water.

2. Solvent weld all joints with manufacturer recommended cement.

3. Overlap all laps and butt joints 1-1/2" minimum. Repair any loose ends that do not seal securely. Solvent weld all fitting covers in the same manner. Final installation shall be watertight.

4. Use plastic insulation covering on all exposed pipes including, but not limited to:

   a. All exposed piping in areas noted on drawings.
   b. All piping in mechanical rooms that is subject to damage from normal operations. (Example: Piping that must be stepped over routinely.)

3.5 SCHEDULE

	Piping System	Insulation Type/Thickness
A.	Geothermal Water Supply & Return	
	All Sizes	B / 1” (2 layers 1/2”)
B.	Heating Water Supply & Return	
	Under 1-1/2"	A / 1-1/2”
	1-1/2" and above	A / 2"
C.	Insulation Inserts at hangers	C - Match pipe insulation thickness

END OF SECTION

SECTION 23 09 00
CONTROLS

TABLE OF CONTENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Complete System of Automatic Controls.
B. Control Devices, Components, Wiring and Material.
C. Instructions for Owners.

1.2 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum five years' experience.

B. TCC: Company specializing in the work of this section with minimum five years temperature control experience.

C. Technician: Minimum five years' experience installing commercial temperature control systems.

D. TCCs are limited to firms regularly employing a minimum of five full-time temperature control technicians within 50 miles of the job site.

1.3 SUBMITTALS

A. Equipment Coordination:

1. The Controls Contractor shall obtain approved equipment submittals from other contractors to determine equipment wiring connections, to choose appropriate controllers, and to provide programming.

2. Control valve selections shall be based on flow rates shown in approved shop drawings.

3. Coordinate the control interface of all equipment with the equipment manufacturers prior to submittal submission.

B. Shop Drawings:

1. Submit shop drawings per Section 23 05 00. In addition, submit an electronic copy of the shop drawings in Adobe Acrobat (.pdf) format to the Owner for review.

2. Cross-reference **all** control components and point names in a single table located at the beginning of the submittal with the **identical** nomenclature used in this section.

3. Submittal shall also include a trunk cable schematic diagram depicting operator workstations, control panel locations and a description of the communication type, media and protocol.

4. System Architecture: Provide riser diagrams of wiring between central control unit and all control panels. This shall include specific protocols associated with each level within the architecture. Identify all interface equipment between CPU and control panels. The architecture shall include interface requirements with other systems including, but not limited to, security systems, lighting control, fire alarm, elevator status, and power monitoring system.

5. Diagrams shall include:

a. Wiring diagrams and layouts for each control panel showing all termination numbers.

b. Schematic diagrams for all control, communication, and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers' model numbers and functions. Show all interface wiring to the control system.

c. Identification of all control components connected to emergency power.

d. Schematic diagrams for all field sensors and controllers.

e. A schematic diagram of each controlled system. The schematics shall have all control points labeled. The schematics shall graphically show the location of all control elements in the system.

f. A schematic wiring diagram for each controlled system. Each schematic shall have all elements labeled. Where a control element is the same as that shown on the control system schematic, label it with the same name. Label all terminals.

g. A tabular instrumentation list for each controlled system. The table shall show element name, type of device, manufacturer, model number and product data sheet number.

h. All installation details and any other details required to demonstrate that the system will function properly.

i. All interface requirements with other systems.

6. The network infrastructure shall conform to the published guidelines for wire type, length, number of nodes per channel, termination, and other relevant wiring and infrastructure criteria as published. The number of nodes per channel shall be no more than 80% of the defined segment (logical or physical) limit in order to provide future system enhancement with minimal infrastructure modifications.

7. Sequences: Submit a complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system. **The wording of the control sequences in the submittal shall match verbatim that included in the construction documents to ensure there are no sequence deviations from that intended by the Architect/Engineer. Clearly highlight any deviations from the specified sequences on the submittals.**

8. Points List Schedule: Submit a complete points list of all points to be connected to the TCS and FMCS. The points list for each system controller shall include both inputs and outputs (I/O), point number, the controlled device associated with the I/O point, the location of the I/O device, and reference drawings. Where a control point is the same as that shown on the control system schematic, label it with the same name. Points list shall specifically identify alarms, trends, event history, archive, totalization, graphic points, and all mapped points from other systems (security systems, lighting control, fire alarm, etc.). Provide points lists, point naming convention, and factory support information for systems provided and integrated into the FMCS.

9. Damper Schedule: Schedule shall include a separate line for each damper and a column for each of the damper attributes:

a. Damper Identification Tag.
b. Location.
c. Damper Type.
d. Damper Size.
e. Duct Size.
f. Arrangement.
g. Blade Type.
h. Velocity.

i. Pressure Drop.
j. Fail Position.
k. Actuator Identification Tag.
l. Actuator Type.
m. Mounting.

10. Valve Schedule: Valve manufacturer shall size valves and create a valve schedule. Schedule shall include a separate line for each valve and a column for each of the valve attributes:

a. Valve Identification Tag.
b. Location.
c. Valve Type.
d. Valve Size.
e. Pipe Size.
f. Configuration.
g. Flow Characteristics.
h. Capacity.
i. Valve C_V.
j. Design Pressure Drop.
k. Pressure Drop at Design Flow.
l. Fail Position.
m. Close-off Pressure.
n. Valve and Actuator Model Number and Type.

11. Airflow Measuring Station Schedule:

a. The manufacturer's authorized representative shall prepare the airflow measuring station submittal, or review and approve in writing the submittal prepared by the TCC prior to submission to the Architect/Engineer and prior to installation. The representative shall review air handling equipment submittals and duct fabrication drawings to ensure that all AFMS locations meet the appropriate parameters to achieve proper installation and the specified accuracy. Comply with all manufacturer's installation requirements including straight up and downstream duct lengths. Install airflow straighteners if required by the manufacturer based on installation constraints. The Architect/Engineer shall be notified for approval of any deviations.

b. Submit product data sheets for airflow measuring devices indicating minimum placement requirements, sensor density, sensor distribution, and installed accuracy to the host control system.

c. Submit installation, operation, and maintenance documentation.

12. Product Data Sheets: Required for each component that includes: unique identification tag that is consistent throughout the submittal, manufacturer's description, technical data, performance curves, installation/maintenance instructions, and other relevant items. When manufacturer's literature applies to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cutsheets to fulfill submittal requirements.

13. Provide PICS files indicating the BACnet® functionality and configuration of each device.

14. Provide documentation of submitted products that have been tested and listed by the BACnet Testing Laboratory (BTL), or provide a letter on the manufacturer's company letterhead indicating the anticipated date by which testing is expected to be completed. If, for any reason, BTL testing and listing has not been completed, a written commitment to upgrade installed controls to a version that meets BTL testing and listing requirements in the event that problems are found during BTL testing is required.

15. Graphic Display: Include a sample graphic of each system and component identified in the points list with a flowchart (site map) indicating how the graphics are to be linked to each other for system navigation.

16. Software: A list of operating system software, operator interface software, color graphic software, and third-party software.

17. Control System Demonstration and Acceptance: Provide a description of the proposed process, along with all reports and checklists to be used.

18. Clearly identify work by others in the submittal.

19. Quantities of items submitted may be reviewed but are the responsibility of the Contractor to verify.

C. Operation and Maintenance Manual:

1. In addition to the requirements of Section 23 05 00, submit an electronic copy of the O&M manuals in PDF format.

2. Provide three complete sets of manuals.

3. Each O&M manual shall include:

a. Table of contents with indexed tabs dividing information as outlined below.

b. Definitions: List of all abbreviations and technical terms with definitions.

c. Warranty Contacts: Names, addresses, and 24-hour telephone numbers of contractors installing equipment and controls and service representatives of each.

d. Licenses, Guarantees, and Warranties: Provide documentation for all equipment and systems.

e. System Components: Alphabetical list of all system components, with the name, address, and telephone number of the vendor.

f. Operating Procedures: Include procedures for operating the control systems; logging on/off; enabling, assigning, and reporting alarms; generating reports; collection, displaying, and archiving of trended data; overriding computer control; event scheduling; backing up software and data files; and changing setpoints and other variables.

g. Programming: Description of the programming language (including syntax), statement descriptions (including algorithms and calculations used), point database creation and modification, program creation and modification, and use of the editor.

h. Engineering, Installation, and Maintenance: Explain how to design and install new points, panels, and other hardware; recommended preventive maintenance procedures for all system components, including a schedule of tasks (inspection, cleaning, calibration, etc.), time between tasks, and task descriptions; how to debug hardware problems; and how to repair or replace hardware. A list of recommended spare parts.

i. Original Software: Complete original issue CDs for all software provided, including operating systems, programming language, operator workstation software, and graphics software.

j. Software: One set of CDs containing an executable copy of all custom software created using the programming language, including the setpoints, tuning parameters, and object database.

k. Graphics: A glossary or icon symbol library detailing the function of each graphic icon and graphics creation and modification. One set of CDs containing files of all color graphic screens created for the project.

D. Training Manual:

1. Provide a course outline and training manuals for each training class.

E. Record Documents:

1. Submit record documentation per Section 23 05 00.

2. Provide a complete set of "as-built" drawings and application software on CDs. Provide drawings as AutoCAD™ or Visio™ compatible files. Provide two copies of the "as-built" drawings with revisions clearly indicated in addition to the documents on compact disk. All as-built drawings shall also be installed on the FMCS server in a dedicated directory. Provide all product data sheets in PDF format.

3. Submit two hard copies and one electronic copy of as-built versions of the shop drawings, including product data and record drawings with revisions clearly indicated. Provide floor plans showing actual locations of control components including panels, thermostats, sensors, and hardware.

4. Provide all completed testing and commissioning reports and checklists, along with all trend logs for each system identified in the points lists.

5. Submit printouts of all graphic screens with current values (temperatures, pressures, etc.) to the A/E verifying completion and proper operation of all points.

1.4 DELIVERY, STORAGE AND HANDLING

A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons through shipping, storage, and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

B. Factory-Mounted Components: Where control devices specified in this section are indicated to be factory mounted on equipment, arrange for shipping control devices to unit manufacturer.

1.5 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Control Valves.
B. Flow Switches.
C. Temperature Sensor Sockets.
D. Gauge Taps.
E. Automatic Dampers.
F. Flow Meters.

1.6 AGENCY AND CODE APPROVALS

A. All products shall have the following agency approvals. Provide verification that the approvals exist for all submitted products with the submittal package.

1. UL-916; Energy Management Systems.
2. C-UL listed to Canadian Standards Association C22.2 No. 205-M1983 "Signal Equipment."

3. EMC Directive 89/336/EEC (European CE Mark).
4. FCC, Part 15, Subpart J, Class A Computing Devices.

1.7 ACRONYMS

A. Acronyms used in this specification are as follows:

1.	B-AAC	BACnet Advanced Application Controller
2.	B-ASC	BACnet Application Specific Controller
3.	BTL	BACnet Testing Laboratories
4.	DDC	Direct Digital Controls
5.	FMCS	Facility Management and Control System
6.	GUI	Graphic User Interface
7.	IBC	Interoperable BACnet Controller
8.	IDC	Interoperable Digital Controller
9.	LAN	Local Area Network
10.	NAC	Network Area Controller
11.	ODBC	Open DataBase Connectivity
12.	OOT	Object Oriented Technology
13.	OPC	Open Connectivity via Open Standards
14.	PICS	Product Interoperability Compliance Statement
15.	PMI	Power Measurement Interface
16.	POT	Portable Operator's Terminal
17.	TCC	Temperature Control Contractor
18.	TCS	Temperature Control System
19.	WAN	Wide Area Network
20.	WBI	Web Browser Interface

1.8 SUMMARY

A. Provide new standalone FMCS for this project with connection to city server system..

B. TCC shall furnish all labor, materials, equipment, and service necessary for a complete and operating Temperature Control System (TCS) and Facility Management and Control System (FMCS) using Direct Digital Controls as shown on the drawings and as described herein.

C. All labor, material, equipment and software not specifically referred to herein or on the plans that is required to meet the intent of this specification shall be provided without additional cost to the Owner.

D. The Owner shall be the named license holder of all software associated with any and all incremental work on the project.

1.9 LEED REQUIREMENTS

A. This project shall meet the requirements of the U.S. GREEN BUILDING COUNCIL LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN (LEED) program.

B. This project will attempt to achieve the U.S. Green Building Council's LEED Version 3.0 certification Level: Silver.

C. This Contractor shall carefully examine the LEED portion of this specification for full compliance with the following LEED points:

1. "Energy & Atmosphere": Prerequisite 1, "Fundamental Building Systems Commissioning," Prerequisite 2 - "Minimum Energy Performance," Credit 3 - "Additional Commissioning," and Credit 5 - "Measurement and Verification," as described by LEED.

2. "Indoor Environmental Quality": Prerequisite 1 - "Minimum IAQ Performance," Credit 1 - "Outdoor Air Delivery Monitoring," Credit 2 - "Increased Ventilation," Credit 6 - "Controllability of Systems," Credit 6.1 - "Lighting Control," and Credit 6.2 - "Thermal Comfort."

3. All labor and materials required for these and any other LEED initiatives shall be provided without additional cost to the Owner.

1.10 SYSTEM DESCRIPTION

A. The entire TCS shall be comprised of a network of interoperable, standalone digital controllers communicating via the following protocol to an NAC. Temperature Control System products shall be as specified below.

B. The FMCS shall include Network Area Controller or Controllers (NAC) within each facility. The NAC shall connect to the Owner's local or wide area network, depending on configuration. Provide access to the system, either locally in each building or remotely from a central site or sites, through standard Web browsers, via the Internet, and/or via local area network.

C. Provide materials and labor necessary to connect factory supplied control components.

D. Provide central and remote hardware, software, and interconnecting wire and conduit.

E. The FMCS shall include automated alarming software capable of calling e-mail compatible cellular telephones and pagers. The e-mail alarm paging system shall be able to segregate users, time schedules, and equipment and be capable of being programmed by the Owner.

F. For the dedicated configuration tool provided, it is preferable that it be launched from within the applicable Network Management Software. If not, include any software required for controller configuration as a leave-behind tool with enough license capability to support the installation.

1.11 SOFTWARE LICENSE AGREEMENT

A. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s). In addition, the Owner shall receive ownership of all job-specific configuration documentation, data files, configuration tools, and application-level software developed for the project. This shall include, but is not limited to, all custom, job-specific software code and documentation for all configuration and programming that is generated for a given project and/or configured for use with the NAC, FMCS Server(s), and any related LAN/WAN/intranet and/or Internet connected routers and devices. Provide the Owner with all required IDs and passwords for access to any component or software program. The Owner shall determine which organizations shall be named in the SI organization ID (**"orgid"**) of all software licenses. Owner shall be free to direct the modification of the **"orgid"** in any software license, regardless of supplier.

1.12 JOB CONDITIONS

A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to ensure that the Work will be carried out in an orderly fashion. It is this Contractor's responsibility to check the Contract Documents for possible conflicts between the Work of this section and that of other crafts in equipment location; pipe, duct and conduit runs; electrical outlets and fixtures; air diffusers; and structural and architectural features.

1.13 WARRANTY

A. Refer to Section 23 05 00 for warranty requirements.

B. Within the warranty period, any defects in the work provided under this section due to faulty materials, methods of installation or workmanship shall be promptly (within 48 hours after receipt of notice) repaired or replaced by this Contractor at no expense to the Owner.

C. Warranty requirements include furnishing and installing all FMCS software upgrades issued by the manufacturer during the one-year warranty period.

D. Update all software and back-ups during warranty period and all user documentation on the Owner's archived software disks.

1.14 WARRANTY ACCESS

A. The Owner shall grant to this Contractor reasonable access to the TCS and FMCS during the warranty period.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

Acceptable Manufacturers	BACnet Protocol
Honeywell WEBs-AX	●

2.2 SYSTEM ARCHITECTURE

A. General:

1. The Temperature Control System (TCS) and Facility Management Control System (FMCS) shall consist of a network of interoperable, standalone digital controllers, a computer system, graphic user interface software, printers, network devices, valves, dampers, sensors, and other devices as specified herein.

2. The installed system shall provide secure password access to all features, functions and data contained in the overall FMCS.

3. The FMCS shall be based on Tridium's Niagara Framework and adhere to the open NICS licensing. The FMCS shall be comprised of Java Application Control Engine or Controllers (JACE) within each facility. The system shall support JACE Version 3.8. The JACE shall connect to the local area network, depending on configuration. Access to the system, either locally in each building, or remotely from a central site or sites, shall be accomplished through standard Web browsers, via the Internet and/or local area network. Each JACE is capable communicate to LonMark/LonTalk (ILC) and/or BACnet (IBC) controllers and other open and legacy protocol systems/devices.

4. The FMCS shall be based on the NiagaraAX Framework (or "NiagaraAX"), a Java-based framework developed by Tridium. NiagaraAX provides an open automation infrastructure that integrates diverse systems and devices (regardless of manufacturer, communication standard or software) into a unified platform that can be easily managed in real time over the Internet using a standard Web browser. Systems not developed on the NiagaraAX Framework platform are unacceptable.

5. The entire Temperature Control System (TCS) shall be comprised of a network of interoperable, stand-alone digital controllers communicating via LonMark/LonTalk and/or BACnet communication protocols to Java Application Control Engines (JACE) which communicate BACnet TCP/ IP or OBIX TCP/IP to the Niagara AX Server. Niagara AX Supervisor Software to be installed on owner provided server.

6. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s). All Niagara AX software licenses shall have the "accept.station.in=*" and "accept.station.out=*"and "accept.wb.in=*" and "accept.wb.out=*" section of the software licenses. The intent is to insure that the installed Niagara AX products may be completely open for integrations. Owner shall be free to direct the modification of any software license, regardless of supplier. In addition, the owner shall receive ownership of all job specific software configuration documentation, data files, and application-level software developed for the project. This shall include all custom, job specific software code and documentation for all configuration and

programming that is generated for a given project and/or configured for use with Niagara Framework (Niagara AX) based controllers and/or servers and any related LAN / WAN / Intranet and Internet connected routers and devices. Any and all required I.D.'s and passwords for access to any component or software program shall be provided to the owner. Provide all software necessary for developing software algorithms in all supervisory, programmable and application specific direct digital controllers which is licensed to the Owner.

B. Open, Interoperable, Integrated Architectures:

1. All components and controllers supplied under this Division shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass data are not acceptable.

2. The supplied system must be able to access all data using standard Web browsers without requiring proprietary operator interface and configuration programs. An Open DataBase Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on a supplier-installed server for all database access. Systems requiring proprietary database and user interface programs are not acceptable.

3. Hierarchical or "flat" topologies are required to have system response times as indicated below and to manage the flow and sharing of data without unduly burdening the customer's internal intranet network.

a. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.

b. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.

2.3 NETWORKS

A. The Local Area Network (LAN) shall be a 100 megabits/sec Ethernet network supporting BACnet, Java, XML, HTTP, and SOAP. Provide support for multiple Network Area Controllers (NACs), user workstations and, if specified, a local server.

B. Local area network minimum physical and media access requirements:

1. Ethernet; IEEE Standard 802.3.
2. Cable; 100 Base-T, UTP-8 wire, Category 6.
3. Minimum throughput; 100 Mbps.

C. Communication conduits shall not be installed closer than six feet from 110VAC or higher transformers or run parallel within six feet of electrical high power cables. Route the cable as far from interference generating devices as possible. Where communication wire must cross 110VAC or higher wire, it must do so at right angles.

D. Ground all shields (earth ground) at one point only to eliminate ground loops. Provide all shield grounding at the controller location, with the shield at the sensor/device end of the applicable wire being left long and "safed" off in an appropriate manner.

E. There shall be no power wiring in excess of 30 VAC rms run in conduit with communications wiring. In cases where signal wiring is run in conduit with communication wiring, run all communication wiring and signal wiring using separate twisted pairs (24awg) in accordance with the manufacturer's wiring practices.

2.4 REMOTE NETWORK ACCESS

A. For Local Area Network installations, provide access to the LAN from a remote location via the Internet. The Owner shall provide a connection to the Internet to enable this access via high speed cable modem, asynchronous digital subscriber line (ADSL) modem, ISDN line, T1 Line or via the customer's intranet to a corporate server providing access to an Internet Service Provider (ISP). Customer agrees to pay monthly access charges for connection and ISP.

2.5 NETWORK AREA CONTROLLER (NAC)

A. The TCC shall supply one or more Network Area Controllers (NAC) as part of this contract. Number of NACs required depends on the type and quantity of devices provided under Divisions 23 and 26. The TCC shall determine the quantity and type of devices.

B. Each NAC shall provide the interface between the LAN or WAN and the field control devices and shall provide global supervisory control functions over the control devices connected to the NAC. It shall execute application control programs to provide:

1. Calendar functions.
2. Scheduling.
3. Trending.
4. Alarm monitoring and routing.
5. Time synchronization.
6. Integration of all controller data.
7. Network Management functions.

C. The Network Area Controller shall provide the following hardware features as a minimum:

1. One Ethernet Port – 10/100 Mbps.
2. One RS-232 port.
3. One LonWorks Interface Port – 78KB FTT-10A (for LonWorks systems only).
4. One RS-485 port.
5. Battery backup.
6. Flash memory for long-term data backup. (If battery backup or flash memory is not supplied, the controller shall contain a hard disk with at least 1 gigabyte storage capacity.)
7. The NAC must be capable of operation over a temperature range of 32°F to 122°F.
8. The NAC must be capable of withstanding storage temperatures of between 0°F and 158°F.
9. The NAC must be capable of operation over a humidity range of 5% RH to 95% RH, non-condensing.

D. The NAC shall provide multiple user access to the system and support for ODBC or SQL. Databases resident on the NAC shall be ODBC-compliant or must provide an ODBC data access mechanism to read and write data stored within it.

E. The NAC shall support standard Web browser access via the Internet or an intranet and a minimum of five (5) simultaneous users.

F. Event Alarm Notification and Actions:

1. The NAC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.

2. The NAC shall be able to route any alarm condition to any defined user location whether connected to a LAN, remote via dial-up telephone connection, or WAN.

3. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including, but not limited to:

a. Alarm

b. Normal

4. Provide for the creation of a minimum of eight alarm classes with different routing and acknowledgement properties, e.g. security, HVAC, Fire, etc.

5. Provide timed (scheduled) routing of alarms by class, object, group, or node.

6. Provide alarm generation from binary object "runtime" and/or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.

G. Treat control equipment and network failures as alarms and annunciated.

H. Annunciate alarms in any of the following manners as defined by the user:

1. Screen message text.

2. E-mail of the complete alarm message to multiple recipients. Provide the ability to route and e-mail alarms based on:

a. Day of week.
b. Time of day.
c. Recipient.

3. Pagers via paging services that initiate a page on receipt of e-mail message.

4. Graphic with flashing alarm object(s).

5. Printed message, routed directly to a dedicated alarm printer.

I. The FMCS shall record the following for each alarm:

1. Time and date.
2. Location (building, floor, zone, office number, etc.).
3. Equipment tag.
4. Acknowledge time, date, and user who issued acknowledgement.
5. Number of occurrences since last acknowledgement.

J. Give defined users proper access to acknowledge any alarm.

K. A log of all alarms shall be maintained by the NAC and/or a server (if configured in the system) and shall be available for review by the user.

L. Provide a "query" feature to allow review of specific alarms by user-defined parameters.

M. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.

N. An error log to record invalid property changes or commands shall be provided and available for review by the user.

2.6 BACNET FMCS

A. The intent of this specification is to provide a peer-to-peer networked, standalone, distributed control system with the capability to integrate ANSI/ASHRAE Standard 135-2001 BACnet, MODBUS, OPC, and other open and proprietary communication protocols in one open, interoperable system.

B. The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices in the system. Adherence to industry standards including the latest ANSI/ASHRAE Standard 135 (BACnet) to assure interoperability between all system components is required. For each BACnet device, the device supplier must provide a PICS document showing the installed device's compliance level. Minimum compliance is Level 3; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet (BACnet Ethernet/IP) and/or RS-485 (BACnet MSTP).

C. Interoperable BACnet Controller (IBC):

1. Controls shall be microprocessor based Interoperable BACnet Controllers (IBC) in accordance with the latest ANSI/ASHRAE Standard 135. Provide IBCs for unit ventilators, fan coils, heat pumps, terminal air boxes (TAB) and other applications. The application control program shall reside in the same enclosure as the input/output circuitry that translates the sensor signals. Provide a PICS document showing the installed system's compliance level to ANSI/ASHRAE Standard 135. Minimum compliance is Level 3.

2. The IBCs shall be listed by the BACnet Testing Laboratory (BTL) as follows:

    a. BACnet Building Controller(s) (B-BC).
    b. BACnet Advanced Application Controller(s) (B-ACC).
    c. BACnet Application Specific Controller(s) (B-ASC).

3. The IBCs shall communicate with the NAC via an Ethernet connection at a baud rate of not less than 10 Mbps.

4. Each IBC sensor shall connect directly to the IBC and shall not use any of the I/O points of the controller. The IBC Sensor shall provide a two-wire connection to the controller that is polarity and wire type insensitive. The IBC sensor shall provide a communications jack for connection to the BACnet communication trunk to which the IBC controller is connected. The IBC sensor, the connected controller, and all other devices on the BACnet bus shall be accessible by the POT.

5. All IBCs shall be fully application programmable and shall at all times maintain their BACnet Level 3 compliance. Controllers offering application selection only (non-programmable) require a 10% spare point capacity to be provided for all applications. Store all control sequences within or programmed into the IBC in non-volatile memory that does not depend on a battery to be retained.

6. The Contractor supplying the IBCs shall provide documentation for each device, with the following information at a minimum:

    a. BACnet Device; MAC address, name, type and instance number.
    b. BACnet Objects; name, type and instance number.

7. It is the responsibility of the Contractor to ensure that the proper BACnet objects are provided in each IBC.

D. Object Libraries

1. A standard library of objects shall be included for development and setup of application logic, user interface displays, system services, and communication networks.

2. The objects in this library shall be capable of being copied and pasted into the user's database and shall be organized according to their function. In addition, the user shall have the capability to group objects created in their application and store the new instances of these objects in a user-defined library.

3. In addition to the standard libraries specified here, the system supplier shall maintain an on-line accessible (over the Internet) library, available to all registered users, to provide new or updated objects and applications as they are developed.

4. All control objects shall conform to the control objects specified in the BACnet specification.

5. The library shall include applications or objects for the following functions, at a minimum:

   a. Scheduling Object: The schedule must conform to the schedule object as defined in the BACnet specification, providing seven-day plus holiday and temporary scheduling features and a minimum of 10 on/off events per day. Data entry to be by graphic sliders to speed creation and selection of on-off events.

   b. Calendar Object: The calendar must conform to the calendar object as defined in the BACnet specification, providing 12-month calendar features to allow for holiday or special event data entry. Data entry to be by graphic "point-and-click" selection. This object must be "linkable" to any or all scheduling objects for effective event control.

   c. Override Object: Provide override object that is capable of restarting equipment turned off by other energy saving programs to maintain occupant comfort or for equipment protection.

   d. Start-Stop Time Optimization Object: Provide a start-stop time optimization object to start equipment just early enough to bring space conditions to desired conditions by the scheduled occupancy time. Also, allow equipment to be stopped before the scheduled unoccupied time just far enough ahead to take advantage of the building's "flywheel" effect for energy savings. Provide automatic tuning of all start-stop time object properties based on historical performance.

   e. Demand Limiting Object: Provide a demand-limiting object that is capable of controlling demand for any selected energy utility (electric, oil, gas, etc.). The object shall be able to monitor a demand value and predict (using a sliding window prediction algorithm) the demand at the end of the user-defined interval period (1 to 60 minutes). This object shall also accommodate a utility meter time sync pulse for fixed interval demand control. Upon a prediction that will exceed the user-defined demand limit (supply a minimum of 6 per day), the demand limiting object shall issue shed commands to either turn off user specified loads or modify equipment setpoints to provide the desired energy reduction. If the list of sheddable equipment is not enough to reduce the demand to below the setpoint, display a message on the user's screen (as an alarm) instructing the user to take manual actions to maintain the desired demand. The shed lists are specified by the user and shall be selectable to be shed in either a fixed or rotating order to control which equipment is shed the most often. Upon suitable reductions in demand, the demand-limiting object shall restore the equipment that was shed in the reverse order in which it was shed. Each sheddable object shall have a minimum and maximum shed time property to provide both equipment protection and occupant comfort.

6. The library shall include control objects for the following functions:

   a. Analog Input Object: Minimum requirement is to comply with the BACnet standard for data sharing. Allow high, low and failure limits to be assigned for alarming. Also, provide a time delay filter property to prevent nuisance alarms caused by temporary excursions above or below the user defined alarm limits.

   b. Analog Output Object: Minimum requirement is to comply with the BACnet standard for data sharing.

   c. Binary Input Object: Minimum requirement is to comply with the BACnet standard for data sharing. The user must be able to specify either input condition for alarming. This object must also include the capability to record equipment runtime by counting the amount of time the hardware input is in an "on" condition. The user must be able to specify either input condition as the "on" condition.

d. Binary Output Object: Minimum requirement is to comply with the BACnet standard for data sharing. Properties to enable minimum on and off times for equipment protection as well as start-to-start delay must be provided. Incorporate the BACnet Command Prioritization priority scheme to allow multiple control applications to execute commands on this object with the highest priority command being invoked. Provide 16 levels of priority as a minimum. Systems not employing the BACnet method of contention resolution are not acceptable.

e. PID Control Loop Object: Minimum requirement is to comply with the BACnet standard for data sharing. Each individual property must be adjustable to allow proportional control only, or proportional with integral control, or proportional, integral and derivative control.

f. Comparison Object: Allow a minimum of two analog objects to be compared to select either the highest, lowest, or equality between the two linked inputs. Also, allow limits to be applied to the output value for alarm generation.

g. Math Object: Allow a minimum of four analog objects to be tested for the minimum or maximum, or the sum, difference, or average of linked objects. Also, allow limits to be applied to the output value for alarm generation.

h. Custom Programming Objects: Provide a blank object template for the creation of new custom objects to meet specific user application requirements. This object must provide a simple BASIC-like programming language that is used to define object behavior. Provide a library of functions including, but not limited to, math and logic functions and string manipulation. Also, provide a comprehensive on-line debug tool to allow complete testing of the new object. Allow new objects to be stored in the library for reuse.

i. Interlock Object: Provide an interlock object that provides a means of coordination of objects within a piece of equipment, such as an air handler or other similar types of equipment. An example is to link the return fan to the supply fan such that, when the supply fan is started, the return fan object is also started automatically without the user having to issue separate commands or to link each object to a schedule object. In addition, the control loops, damper objects, and alarm monitoring (such as return air, supply air, and mixed air temperature objects) will be inhibited from alarming during a user-defined period after startup to allow for stabilization. When the air handler is stopped, the interlocked return fan is also stopped, the outside air damper is closed, and other related objects within the air handler unit are inhibited from alarming, thereby eliminating nuisance alarms during the off period.

j. Temperature Override Object: Provide an object whose purpose is to override a binary output to an “on” state in the event a user-specified high or low limit value is exceeded. Link this object to the desired binary output object as well as to an analog object for temperature monitoring to cause the override to be enabled. This object will execute a start command at the Temperature Override level of start/stop command priority, unless changed by the user.

k. Composite Object: Provide a container object that allows a collection of objects representing an application to be encapsulated to protect the application from tampering or to more easily represent large applications. This object must have the ability to allow the user to select the appropriate parameters of the “contained” application that are represented on the graphic shell of this container.

7. The object library shall include objects to support the integration of devices connected to the Network Area Controller (NAC). Provide the following as part of the standard library included with the programming software:

a. LonMark/LonWorks Devices: These devices shall include, but not be limited to, devices for control of HVAC, lighting, access, and metering. Provide LonMark manufacturer-specific objects to facilitate simple integration of these devices. Support all network variables defined in the LonMark profile. The device manufacturer shall provide information (type and function) regarding network variables not defined in the LonMark profile.

b. For devices not conforming to the LonMark standard, provide a dynamic object that can be assigned to the device based on network variable information provided by the device manufacturer. Device manufacturer shall provide an XIF file, resource file, and documentation for the device to facilitate device integration.

c. For BACnet devices, provide the following objects:

1) Analog In.
2) Analog Out.
3) Analog Value.
4) Binary.
5) Binary In.
6) Binary Out.
7) Binary Value.
8) Multi-State In.
9) Multi-State Out.
10) Multi-State Value.
11) Schedule Export.
12) Calendar Export.
13) Trend Export.
14) Device.

d. For each BACnet object, provide the ability to assign the object a BACnet device and object instance number.

e. For BACnet devices, provide the following support at a minimum:

1) Segmentation.
2) Segmented Request.
3) Segmented Response.
4) Application Services.
5) Read Property.
6) Read Property Multiple.
7) Write Property.
8) Write Property Multiple.
9) Confirmed Event Notification.
10) Unconfirmed Event Notification.
11) Acknowledge Alarm.
12) Get Alarm Summary.
13) Who-has.
14) I-have.
15) Who-is.
16) I-am.
17) Subscribe COV.
18) Confirmed COV notification.
19) Unconfirmed COV notification.
20) Media Types.
21) Ethernet.
22) BACnet IP Annex J.
23) MSTP.

24) BACnet Broadcast Management Device (BBMD) function.
25) Routing.

2.7 TERMINAL AIR BOX (TAB) CONTROLLERS

A. FMCS Volume Controller: Electronic, furnished and installed by TCC. Boxes shall have pressure independent control to maintain constant air volume regardless of duct pressure changes up to 6 inches w.c. Provide velocity and static sensor at box inlet for use by unit controller. Set boxes for maximum and minimum settings shown on the drawings. Refer to Section 23 36 00 for additional information.

B. The controller shall support various digital and analog inputs and outputs as needed for damper control, control valves, electric coils, airflow sensors, remote heating, occupancy sensors, etc. and shall be capable of independent occupancy scheduling.

C. Controller shall provide continuous zone temperature histories internal to device for up to 24 hours and perform its own limit and status monitoring and alarms to limit unnecessary communications.

D. Operator interface to any ASC point data or programs shall be through network resident programs or portable operator's terminal connected to the specific controller.

E. Store all system setpoints, proportional bands, control algorithms, and other programmable parameters such that a power failure of any duration does not necessitate reprogramming of the controller.

F. BACnet TAB controllers shall either be B-AAC devices or B-ASC devices as required to meet the performance and BTL listing.

2.8 DATA COLLECTION AND STORAGE (TRENDING REQUIREMENTS)

A. The NAC shall be able to collect data for any property of any object and store resident in the NAC that shall have, at a minimum, the following configurable properties:

1. Designating the log as interval or deviation.

2. For interval logs, configure the object for time of day, day of week and the sample collection interval.

3. For deviation logs, configure the object for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.

4. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full or rollover the data on a first-in, first-out basis.

5. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.

B. Store all log data in a relational database in the NAC that is accessible from a server (if the system is so configured) or a standard Web browser.

C. All log data, when accessed from a server, shall be capable of being manipulated using standard SQL statements.

D. All log data shall be available to the user in ALL the following data formats:

1. HTML.
2. XML.
3. Plain text.
4. Comma or tab separated values.

E. The NAC shall archive its log data either locally (to itself) or remotely to a server or other NAC on the network. Provide the ability to configure the following archiving properties:

1. Archive on time of day.
2. Archive on user-defined number of data stores in the log (buffer size).
3. Archive when log has reached its user-defined capacity of data stores.
4. Provide ability to clear logs once archived.

2.9 AUDIT LOG

A. Provide and maintain an audit log that tracks all activities performed on the NAC. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached its user-defined buffer size. Provide the ability to archive the log locally (to the NAC), to another NAC on the network, or to a server. For each log entry, provide the following data:

1. Time and date.
2. User ID.
3. Change or activity: i.e., change setpoint, add or delete objects, commands, etc.

2.10 DATABASE BACKUP AND STORAGE

A. The NAC shall automatically backup its database on a user-defined time interval.

B. Store copies of the current database and, at the most, the recently saved database in the NAC. The age of the most recently saved database shall depend on the user-defined database save interval.

C. Store the NAC database in XML format to allow viewing and editing. Other formats are acceptable as long as XML format is supported.

2.11 GRAPHIC USER INTERFACE SOFTWARE

A. Operating System:

1. Provide computer with the most current Microsoft-based operating system with which the GUI has proven compatibility.

B. The GUI shall employ browser-like functionality for ease of navigation. It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database. In addition, menu pulldowns and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with basic computing skills. These shall include, but are not limited to, forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line) that displays the location and the selected object identification.

C. Point Organization: Organize points by equipment categories, location, or other means acceptable to Owner.

D. Real-Time Displays: The GUI shall support the following graphic features and functions:

1. Graphic screens shall be developed using any drawing package capable of generating a GIF, BMP, or JPG file. Use of proprietary graphic file formats is not acceptable. In addition to, or in lieu of, a graphic background, the GUI shall support the use of scanned pictures.

2. Graphic screens shall be able to contain objects for text, real-time values, animation, color spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URLs, and links to other graphic screens.

3. Graphics shall support layering, and each graphic object shall be configurable for assignment to a layer. A minimum of six layers shall be supported.

4. Modifying common application objects, such as schedules, calendars, and setpoints, shall be accomplished graphically.

   a. Schedule times shall be adjusted using a graphic slider without requiring any keyboard entry from the operator.

   b. Holidays shall be set by using a graphic calendar without requiring any keyboard entry from the operator.

5. Commands to start and stop binary objects shall be made by selecting the object and the appropriate command from a pop-up menu. No text entry shall be required.

6. Adjustments to analog objects, such as setpoints, shall be made by selecting the object and using a graphic slider to adjust the value. No text entry shall be required.

E. System Configuration: At a minimum, the GUI shall include the necessary software and components to enable the operator to perform the following tasks with proper password access:

1. Create, delete or modify control strategies.
2. Add/delete objects.
3. Tune control loops by adjusting control loop parameters.
4. Enable or disable control strategies.
5. Generate hard copy records or control strategies on a printer.
6. Select alarm points and define the alarm state.
7. Select points to be trended and initiate the recording of values automatically.
8. View any trend as a graph.

F. On-Line Help: Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext. All system documentation and help files shall be in HTML format.

G. Security: Each operator shall be required to log on to that system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system administrator shall be able to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operator's access for viewing and/or changing each system application, full screen editor, and object. Each operator shall be automatically logged off the system if no keyboard or mouse activity is detected. This auto log-off time shall be set per operator password. Store all system security data in an encrypted format.

H. System Diagnostics: The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. Annunciate the failure of any device to the operator.

I. Alarm Console:

1. The system shall have a dedicated alarm window or console. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and to acknowledge the alarm.

2. When the alarm console is enabled, a separate alarm notification window will supersede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and un-acknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator are not acceptable. The use of the alarm console can be enabled or disabled by the system administrator.

2.12 WEB BROWSER CLIENTS

A. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™, Firefox™, or Chrome. Systems requiring additional software to enable a standard Web browser to reside on the client machine, or manufacturer-specific browsers, are not acceptable.

B. The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphic User Interface. Systems that require different views or that require different means of interacting with objects, such as schedules or logs, are not permitted.

C. The Web browser client shall provide:

1. User log-on identification and password shall be required. If an unauthorized user attempts access, display a blank web page. Implement security using Java authentication and encryption techniques to prevent unauthorized access.

2. Graphic screens developed for the GUI shall be the same screens used for the Web browser client. The web browser interface shall support all animated graphic objects supported by the GUI.

3. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.

4. Store all graphic screens in the Network Area Controller (NAC) without requiring any graphics storage on the client machine.

5. Real-time values displayed on a Web page shall update automatically without requiring a manual "refresh" of the Web page.

6. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:

   a. Modify common application objects, such as schedules, calendars, and setpoints, graphically.

      1) Schedule times shall be adjustable using a graphic slider, without requiring any keyboard entry from the operator.

      2) Holidays shall be set using a graphic calendar, without requiring any keyboard entry from the operator.

   b. Commands to start and stop binary objects shall be made by right-clicking the selected object and selecting the appropriate command from a pop-up menu. No text entry shall be required.

   c. View logs and charts.

   d. View and acknowledge alarms.

   e. Setup and execute SQL queries on log and archive information

7. The system shall be able to specify a user's (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just his/her defined home page. From the home page, links to other views or pages in the system shall be possible, if allowed by the system administrator.

8. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on intranet sites by specifying the Uniform Resource Locator (URL) for the desired link.

2.13 UNINTERRUPTIBLE POWER SUPPLY (UPS)

A. A UPS shall be provided for each of the following:

1. FMCS workstations and servers.
2. Network area controllers.
3. Chiller plant manager.
4. Boiler plant manager.

B. Provide a 120 volt 60 Hz line-interactive uninterruptible power supply with backup battery capacity for 5 minutes at 100% load. UPS shall have hot swappable batteries, automatic battery self-test and start-on-battery capabilities. Batteries shall be valve regulated, sealed lead acid type. UPS shall have sine wave shape output waveform. UPS shall be UL 1778 list and comply with FCC Part 15, Class A.

C. Acceptable Manufacturers: Sola/Hevi-Duty, Eaton Powerware, APC.

2.14 SYSTEM PROGRAMMING

A. The GUI software shall perform system programming and graphic display engineering. Access to the GUI software shall be through password access as assigned by the system administrator.

B. Provide a library of control, application, and graphic objects to enable creation of all applications and user interface screens. Applications shall be created by selecting the control objects from the library, dragging or pasting them on the screen, and linking them together using a built-in graphic connection tool. Completed applications may be stored in the library for future use. GUI screens shall be created in the same fashion. Data for the user displays shall be obtained by graphically linking the user display objects to the application objects to provide “real-time” data updates. Any real-time data value or object property may be connected to display its current value on a user display. Provide all software tools or processes to create applications and user interface displays.

C. Programming Methods

1. Provide the capability to copy objects from the supplied libraries or from a user-defined library to the user’s application. Link objects with a graphic linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one, or one-to-many relationships. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification. Links will vary in color depending on the type of link; e.g., internal, external, hardware, etc.

2. Configuration of each object shall be done through the object’s property sheet using fill-in-the-blank fields, list boxes, and selection buttons. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration is not acceptable.

3. The software shall provide the ability to view the logic in a monitor mode. When on-line, the monitor mode shall provide the ability to view the logic in real time for easy diagnosis of the logic execution. When off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system.

4. All programming shall be done in real time. Systems requiring the uploading, editing, and downloading of database objects are not allowed.

5. The system shall support object duplication in a customer’s database. An application, once configured, can be copied and pasted for easy reuse and duplication. All links, other than to the hardware, shall be maintained during duplication.

2.15 DDE DEVICE INTEGRATION

A. The NAC shall support the integration of device data via Dynamic Data Exchange (DDE) over the Ethernet network. The NAC shall act as a DDE client to another software application that functions as a DDE server.

B. Provide the required objects in the library included with the Graphic User Interface programming software to support the integration of these devices into the FMCS. Objects provided shall include, at a minimum:

1. DDE Generic AI Object.
2. DDE Generic AO Object.
3. DDE Generic BO Object.
4. DDE Generic BI Object.

2.16 MODBUS SYSTEM INTEGRATION

A. The NAC shall support integration of device data from Modbus RTU, ASCII, and TCP control system devices. Connect to the Modbus system via an RS-232, RS485, or Ethernet IP as required by the device.

B. Provide the required objects in the library included with the GUI programming software to support the integration of the Modbus system data into the FMCS. Objects provided shall include, at a minimum:

1. Read/Write Modbus AI Registers.
2. Read/Write Modbus AO Registers.
3. Read/Write Modbus BI Registers.
4. Read/Write Modbus BO Registers.

C. The NAC shall perform all scheduling, alarming, logging and global supervisory control functions of the Modbus system devices.

D. The FMCS supplier shall provide a Modbus system communications driver. The equipment system vendor that provided the equipment using Modbus shall provide documentation of the system's Modbus interface and shall provide factory support at no charge during system commissioning.

2.17 SOFTWARE

A. IDC/IBCs shall operate totally standalone and independent of a central computer for all specified control applications.

B. Software shall include a complete operating system (OS), communications handler, point processing, energy management application packages as specified herein, standard control algorithms and specific control sequences (IDC/IBC) and an Owner/user custom control calculation package complete with interpreter.

C. OS software shall be PROM resident, operate in real time, provide prioritized task scheduling, control time programs, monitor and manage communications, and scan inputs and outputs.

D. Each IDC/IBC panel shall include the following energy management routines:

1. Time of day scheduling.
2. Optimum start/stop.
3. Peak demand limiting.
4. Economizer control.
5. PID control.
6. Supply air reset.
7. Outdoor air reset.

E. Input/output point processing software shall include:

1. Update of all connected input and output points at least once per second.

2. Analog to digital conversion, scaling and offset, correction of sensor non-linearity, sensing no response or failed sensors, and conversion of values to 32-bit floating point format. Retain both the maximum and minimum values sensed for each analog input in memory. It shall be possible to input subsets of standard sensor ranges to the A/D converter and assign gains to match the full-scale 32-bit conversion to achieve high accuracy readout.

3. A reasonability check on all analog inputs against previous values and discarding of values falling outside preprogrammed reasonability limits.

4. Assignment of proper engineering units and status conditions to all inputs and outputs.

5. Analog input alarm comparison with the ability to assign two individual sets of high and low limits (warning and alarm) to an input or to assign a set of floating limits (alarm a reset schedule or FMCS control point) to the input. Assign each alarm a unique differential to prevent a point from oscillating in and out of alarm. Make alarm comparisons of each scan cycle.

6. Adjustment of timing from two seconds to two minutes in one-second increments to eliminate nuisance alarms on startup.

F. Command Control software shall manage the receipt of commands from the server and from control programs.

1. Provide command delay to prevent simultaneous energizing of loads. Delay must be programmable from 0 to 30 seconds.

2. Assign each command a command and residual priority to manage conflicts created by multiple programs having access to the same command point. Allow only outputs with a higher command priority to execute. Whenever a command is allowed to execute, its assigned residual priority shall replace the existing residual priority.

3. A "fixed mode" option (override) shall allow inputs to and outputs from control programs to set to a fixed state or value. When in the "fixed mode", assign inputs and outputs high residual command priority to prevent override by application programs.

G. Alarm lockout software shall prevent nuisance alarms. On initial start-up of mechanical equipment, assign a "timed lockout" period to analog points to allow them to reach a stable condition before activating alarm comparison logic. Lockout period shall be programmable for each point from 0 to 90 minutes in one-minute increments.

H. A "hard lockout" shall also be provided to positively lock out alarms when equipment is turned off or when a true alarm depends on the condition of an associated point. Hard lockout points and lockout initiators shall be operator programmable.

I. Runtime shall be accumulated based on the status of a digital input point. It shall be possible to totalize either on time or off time up to 10,000 hours with one-minute resolution. Runtime counts shall reside in non-volatile memory and have DCP resident runtime limits assignable through the operator's terminal.

J. A transition counter shall count the number of times a device is cycled on or off. Counter shall be non-volatile and capable of counting 600,000 cycles. Limits shall be assignable to counts to provide maintenance alarm printouts.

K. Custom IDC/IBC programs shall meet the control strategies called for in the sequence of operation of these specifications. Each IDC/IBC shall have resident in its memory and available to the programs a full library of IDC/IBC algorithms, intrinsic control operators, arithmetic, logic, and relational operators. Provide the following features:

1. Proportional Control, Proportional plus Integral (PI), Proportional plus Integral plus Derivative (PID), and Adaptive Control (self-learning). Use Adaptive Control where the controlled flow rate is

variable (such as TAB units and variable flow pumping loops). The adaptive control algorithm shall monitor the loop response to output corrections and adjust the loop response characteristics in accordance with the time constant changes imposed by variable flow rates. The algorithm shall operate in a continuous self-learning manner and shall retain in memory a stored record of the system dynamics so that, on system shutdown and restart, the learning process starts from where it left off. Standard PID algorithms are not acceptable substitutes for variable flow applications since they will provide satisfactory control at only one flow rate and will require continued manual fine tuning.

2. All IDC/IBC setpoints, gains and time constants associated with IDC/IBC programs shall be available to the operator for display and modification via the operator workstation.

3. The execution interval of each IDC/IBC loop shall be adjustable from 2 to 120 seconds in one-second increments.

4. IDC/IBC control programs shall assign initialization values to all outputs so controlled devices assume a failsafe position on start-up.

L. Provide time and event programming (TEP) capability to initiate a controlled sequence of events for execution at a specific time or upon the occurrence of an event. Minimum program features required are:

1. Analog points commandable to a specific value.

2. Digital points commandable to a specific state; e.g. on or off; fast, slow or off.

3. Initiator to be a specific day and time or a specific event; e.g. an alarm.

4. Manual initiation via operator's command.

5. Commands must honor command delays (to prevent current surges), and assigned minimum ON and OFF times.

6. Commands must honor command and residual priority structures allowing higher priority commands (like smoke control) to override lower priority commands (like time of day scheduling) and residual priority.

7. Ability to chain TEPs.

8. Ability to enable and disable TEPs individually.

9. Ability to enable/disable TEP initiators.

M. Store Energy Management application programs and associated data files in non-volatile or 72-hour battery backed RAM memory. Individual programs shall be accessible from the operator workstation for enabling/disabling and program parameter modification and shall include:

1. Time Programs:

a. Provide an independent start and stop program time for each system identified in the points list.

b. It shall be possible to assign two independent start and stop times/days to any equipment connected to a controller.

2. Exception Day Scheduling:

a. Provide an Exception Day program for holiday and other planned exceptions to time programs. Exception schedules shall be DSC resident and operator programmable up to one year in advance.

b. The program shall allow definition of up to 32 exception time spans. Define each span by calendar start day and calendar stop day.

3. An IDC/IBC resident temporary scheduler shall allow operators to modify present time program control of equipment. Minimum feature set required is:

a. Ability to alter time schedules as much as six days in advance.

b. Ability to alter either start time, stop time or both for each day.

c. Temporary schedule shall be in effect for all days specified.

d. Automatically delete the temporary schedule and restore program to normal schedule after execution.

e. Ability to assign schedule changes as permanent as well as temporary.

N. The IDC/IBC shall have built-in, non-descriptive, self-test procedure for checking the indication lights, digital display, and memory. It shall display advisories for maintenance, performance, and/or software problems.

O. All electronics shall be:

1. Standard locally stocked modular boards.
2. Plug-in type.
3. Furnish all ROM programs unlocked.

2.18 CONTROL DAMPERS

A. Rectangular Control Dampers - Standard Construction:

1. Shall be licensed to bear the AMCA Certified Rating Seal.

2. Test leakage and pressure drop per AMCA 500.

3. Frame: Hat-shaped channel, minimum 12 gauge extruded aluminum, and minimum 4" deep. Caulk or weld seams to prevent leakage.

4. Blades: Minimum 12 gauge extruded aluminum airfoil design, minimum 6" wide, and overlapping blades and blade seals (overlapping blade seals only is unacceptable).

5. Shaft: Non-cylindrical, solid aluminum shaft with opening in blade to match profile of shaft. Shaft shall be securely fastened to the blade and of sufficient length to mount direct-coupled actuator. Damper manufacturer shall provide drive pin extensions and outboard bearing support brackets as required.

6. Bearings: Acetal (Delrin/Celcon) inner bearing fixed to an aluminum shaft, rotating within a polycarbonate outer bearing inserted in the frame. Provide thrust bearings for vertical damper applications.

7. Blade Seals: Extruded silicone gaskets secured in an integral slot within the blade.

8. Side Seals: Stainless steel compression type or extruded silicone gasket secured in an integral slot within the frame.

9. Linkage: Shall be concealed in the frame, constructed of aluminum or corrosion-resistant zinc plated steel, and securely fastened to shaft. Blades linked for opposed operation, unless noted otherwise on the drawings. Blades shall close evenly. Use one direct-coupled actuator per damper section. Jack-shafting is not acceptable.

10. Size Limits: 48" maximum horizontal blade length, 24 square foot maximum area per damper. Total cross-sectional area of dampers in ducts shall be at least as large as the duct without the use of blank-off sections.

11. Damper shall be maintenance free Leakage Class 1A.

12. Maximum Pressure Drop for Opposed Blade Damper: 0.15" for 8,000 cfm through a 24"x24" damper (2000 fpm).

13. Maximum Pressure Drop for Parallel Blade Damper: 0.08" for 8,000 cfm through a 24"x24" damper (2000 fpm).

B. Thermally Insulated Control Damper:

1. Shall be licensed to bear the AMCA Certified Rating Seal.

2. Test leakage and pressure drop per AMCA 500.

3. Frame: Extruded aluminum, minimum 4” deep, 0.080” minimum thickness. Frame shall be insulated with Styrofoam on three sides if installed in duct and four sides if flanged to duct.

4. Blades: Minimum 12 gauge extruded aluminum airfoil design, minimum 6” wide, internally insulated with expanded polyurethane foam and thermally broken, with overlapping blades and blade seals (overlapping blade seals only is unacceptable).

5. Shaft: Non-cylindrical, solid aluminum shaft with opening in blade to match profile of shaft. Shaft shall be securely fastened to the blade and of sufficient length to mount direct-coupled actuator. Damper manufacturer shall provide drive pin extensions and outboard bearing support brackets as required.

6. Bearings: Acetal (Delrin/Celcon) inner bearing fixed to an aluminum shaft, rotating within a polycarbonate outer bearing inserted in the frame. Provide thrust bearings for vertical damper applications.

7. Side Seals: Stainless steel compression type or extruded silicone gasket secured in an integral slot within the frame.

8. Linkage: Shall be concealed in the frame, constructed of aluminum or corrosion-resistant zinc plated steel, and securely fastened to shaft. Blades linked for opposed operation, unless noted otherwise on the drawings. Blades shall close evenly. Use one direct-coupled actuator per damper section. Jack-shafting is not acceptable.

9. Size Limits: 48" maximum horizontal blade length, 24 square foot maximum area per damper. Total cross-sectional area of dampers in ducts shall be at least as large as the duct without the use of blank-off sections.

10. Damper shall be rated for conditions of -40°F.

11. Maximum Leakage: Damper shall be maintenance free Leakage Class 1A.

12. Maximum Pressure Drop: 0.21" for 8,000 cfm through a 24"x24" damper (2000 fpm).

2.19 DAMPER ACTUATORS

A. Damper Actuators - Electronic - Spring Return:

1. Damper actuators shall be UL listed, electronic direct coupled with spring return to normal position for modulating or two-position control as noted in the sequence of control. Actuator shall be 24 VAC with proportional control, electronic overload protection to prevent actuator damage due to over-rotation and "V" bolt clamp with matching "V" toothed cradle (single bolt or setscrew fasteners not acceptable).

2. Following power interruption, spring return mechanism shall close the damper. Mechanical spring shall be rated for a minimum of 60,000 full cycles. Provide breathable membrane in actuator housing to compensate for pressure differential and allow for 95% non-condensing relative humidity in the airstream.

3. Mount actuators with motor outside of airstream whenever possible. Unit casings shall have housing with proper weather, corrosive, or explosion-proof construction as required by application.

4. Actuators shall be rated for 60,000 full cycles at rated torque with 2-year unconditional warranty. Size actuators per damper manufacturer's recommendations.

5. Provide end switches as required for the sequence of operation.

6. Provide analog feedback signal for positive position indication. Refer to FMCS points list.

7. Acceptable manufacturer: Honeywell or Belimo

2.20 HYDRONIC CONTROL VALVES

A. General:

1. All control valves shall be pressure independent type control valves.

2. Two-position valves shall be a minimum of line size with a maximum allowable pressure drop of 2 psi.

3. Size two-way and three-way modulating valves to provide a pressure drop at full flow of 1 to 4 psi, except boiler three-way and cooling tower bypass valves shall not have a pressure drop over 2 psi.

4. Two-way valves shall be 100% tight-closing. Three-way valves shall be 100% tight-closing in both extreme positions.

5. Modulating two-way valves shall have equal percentage flow characteristics.

6. Modulating three-way valves shall have linear flow characteristics.

7. Piping geometry correction factors for C_v ratings shall be used and stated for ball valves or non-characterized valves.

B. Two-position:

1. Ball 2" and under:

a. Design Pressure: 400 psi

Design Temperature: 212ºF
Design Flow Differential Pressure Rating: 150 psi

b. Bronze or brass body, stainless steel stem, chrome plated brass or stainless steel full port ball, PTFE or RTFE seats and seals, screwed ends (solder ends are acceptable only if rated for soldering in line with 470ºF melting point of 95-5 solder).

2. Ball 3" to 6":

a. Design Pressure: 200 psi

Design Temperature: 212ºF
Design Flow Differential Pressure Rating: 35 psi

b. Cast iron body, stainless steel stem, stainless steel full port ball, PTFE or RTFE seats and seals, flanged ends.

C. Modulating:

1. Ball 2" and under:

a. Design Pressure: 400 psi

Design Temperature: 212ºF
Design Flow Differential Pressure Rating: 35 psi

b. Bronze or brass body, nickel plated brass or stainless steel stem, chrome plated brass or stainless steel ball, PTFE or RTFE seats and seals, screwed ends (solder ends are acceptable only if rated for soldering in line with 470ºF melting point of 95-5 solder).

2. Ball 3" to 6":

a. Design Pressure: 200 psi

Design Temperature: 212ºF
Design Flow Differential Pressure Rating: 35 psi

b. Cast iron body, stainless steel stem, stainless steel full port ball, PTFE or RTFE seats and seals, flanged ends.

2.21 VALVE ACTUATORS

A. General:

1. Actuators shall be sized to operate the valve through its full range of motion and shall close against pump shutoff pressure without producing audible noise at any valve position.

2. Provide visual position indication.

3. Mount actuator directly on valve or provide linear motion assembly as required for valve type.

B. Valve Actuators - Electronic:

1. Actuator shall be UL listed and provided with NEMA housing for applicable environment, electronic overload protection to prevent actuator damage due to over-rotation, and "V" bolt clamp with matching "V" toothed cradle (single bolt or setscrew fasteners not acceptable).

2. Actuators shall be rated for 60,000 full stroke cycles at rated torque. Stall motor not acceptable.

3. Tri-state/floating actuators shall have auto-zeroing function for realigning valve position.

4. Proportional actuator position shall be proportional to analog or pulse width modulating signal from electronic control system.

5. Spring return actuators shall have an internal spring return mechanism. Non-mechanical forms of fail-safe operation are not acceptable.

6. Provide analog feedback signal for positive position indication as required by control diagrams.

7. Acceptable Manufacturer: Honeywell or Belimo.

2.22 CONTROL INSTRUMENTATION

A. Temperature Measuring Devices:

1. Electric Thermostats:

a. Single Temperature - Line Voltage Electric: Integral manual ON/OFF/AUTO selector switch, minimum dead band of 5ºF, concealed temperature adjustment, locking cover, rated for load, single or double pole as required.

b. Single Temperature - Low Voltage Electric: Integral manual ON/OFF/AUTO selector switch, minimum dead band of 5ºF, anticipator circuits, concealed temperature adjustment, locking cover, 24 V control transformer (if not included with unit under control), single or double pole as required.

2. Low Limit Switch:

a. Provide one foot of sensing element for each one square foot of coil area, maximum element length 25 feet, of the vapor tension type, so that any point along the entire length of measuring element is capable of triggering the switch.

b. Provide 3" minimum radius capillary support clips at each turn.

c. Furnish each thermostat with one single pole, single throw normally-opened switch and one single pole, single throw normally-closed auxiliary switch.

d. Setpoint range shall be 15ºF to 55ºF with a permanent stop at 35ºF.

e. Differential shall be fixed at approximately 5ºF and supplied with manual reset.

B. Temperature Sensors:

1. Room Temperature Sensor:

a. Sensor Only: Honeywell TR23, Two-piece construction, ventilated plastic enclosure, off-white color, thermistor sensing element or resistance temperature device (RTD), 45°F to 90°F operating range, ± 0.50°F accuracy, no setpoint adjustment or override button.

b. Sensor with Setpoint Adjustment: Honeywell TR 71, Two-piece construction, ventilated plastic enclosure, off-white color, thermistor sensing element or resistance temperature device (RTD), 45°F to 90°F operating range, ± 0.50°F accuracy, with exposed single setpoint adjustment (no numeric temperature scale – provide with a single warmer/cooler or red/blue visual scale), no override button.

c. Sensor with Override: Honeywell TR 71, Two-piece construction, ventilated plastic enclosure, off-white color, thermistor sensing element or resistance temperature device (RTD), 45°F to 90°F operating range, ± 0.50°F accuracy, occupied/unoccupied override button with LED, no setpoint adjustment.

d. Sensor with Setpoint Adjustment and Override: Honeywell TR 71, Two-piece construction, ventilated plastic enclosure, off-white color, thermistor sensing element or resistance temperature device (RTD), 45°F to 90°F operating range, ± 0.50°F accuracy, with exposed single setpoint adjustment (no numeric temperature scale – provide with a warmer/cooler or red/blue visual scale), occupied/unoccupied override button with LED.

2. Duct Temperature Sensor:

a. Thermistor or RTD type with 20K ohm rating. Pneumatic transmitters with transducers are not acceptable.

3. Water Temperature Sensor:

a. Install in immersion wells. Separate thermometers as specified elsewhere, also of the immersion well type, shall be installed within 2 feet of each temperature sensor.

4. In-slab Temperature Sensor

a. Slab sensor designed to measure temperature in concrete. Unit shall have high density polyethylene sleeve for use in conduits. Unit shall be supplied with 20 feet of 2 conductor cable. Operating range is -60°F to 140°F. Unit shall be 10K thermistor and be water resistant.

b. Acceptable Manufacturer: Tekmar 072

C. Humidity Measuring Devices:

1. Humidity Sensors:

a. Humidity Sensors: Fully electronic with no moving parts or parts requiring periodic service. Accuracy shall be ± 2% of reading.

D. Pressure Measuring Devices

1. Differential Pressure Switches:

a. Standard Pressure Switches:

1) Diaphragm-activated gauge with 4-3/4" dial, cast aluminum case, sealed interior, designed to resist shock and vibration, and rated for 15 psig.

2) Accuracy shall be ± 3% of full scale maximum throughout entire range at 70ºF.

3) Provide mounting brackets, probes, and shutoff valves required for proper installation.

4) The range and service shall be as required for application or as noted on the drawings.

5) Provide two (2) photo-transistor-activated circuits and two (2) DPDT relays for both high or low limit alarms or controls.

6) Provide latching relays that require manual reset once activated.

7) Acceptable Manufacturer: Dwyer Photohelic Series 3000.

b. High Pressure Switches (Manual Reset):

1) Differential pressure switch with single pole, double-throw snap switch and enclosure.

2) Rated for pressure specified in sequence of control.

3) Electrical rating shall be 15 amps at 120-480 volts.

4) Setpoint adjustment shall be screw type located inside enclosure.

5) Provide optional manual reset for overpressure protection with all tubing, brackets, and adapters.

6) Repeatability: ± 3%.

2. Pressure Transmitters/Transducer:

a. Select device suitable for intended application; water or air, static or differential.

b. Select for appropriate range, including negative if applicable.

c. 100% solid state device, temperature compensated, suitable for pressures of 200% rated range with averaging to stabilize output, accuracy of ± 1% full scale, and a 4-20 mA output.

d. Provide a NEMA 4 enclosure unless panel mounted.

e. Air service shall have a minimum of three field selectable ranges.

f. When used for room pressure control, the transducer shall be bidirectional with a range of ± 0.1" W.C.

g. Provide pressure line outlet cover on both sides of the wall when used for room pressure control.

h. Furnish with integral LED's to indicate Zero Pressure, Pressure In Range, and Pressure Out Of Range as a diagnostic aid.

E. Flow Measuring Devices:

1. Flow Switches:

a. Suitable for the intended application (water or air system).

b. Vane Operated Flow Switch: Vane motion shall activate a single pole, double throw snap switch.

2. Insertion Type Electromagnetic Flow Meter:

a. General:

1) Each flow meter shall be of the magnetic insertion type.

b. Service:

1) Heating Water: Rated for minimum of 240°F service.

c. Insertion Type Electromagnetic Flow Meter:

1) Each meter shall be rated for system pressure and shall have adequate structural integrity for a flow rate equal to 150% of the scheduled maximum initial or future flow rate, whichever is greater.

2) Each insertion type electromagnetic flow meter shall be complete with all hardware necessary to enable insertion and removal of the meter without system shutdown. The flow meter shall be hand insertable up to 400 PSI.

3) Construction:

a) Wetted Components: 316 stainless steel
b) Sensor Head: Polypropylene
c) Electronics enclosure shall be NEMA 4 and aluminum.

4) Each meter shall be wet calibrated against a primary volumetric standard that is accurate to within 0.1% and traceable to NIST.

d. Output:

1) Output signals shall be completely isolated and shall consist of the following:

a) High resolution frequency output for use with peripheral devices such as display module or BTU meter.

b) Analog output; 4-20mA, 0-10V, or 0-5V jumper selectable.

c) Scalable dry contact output for totalization.

2) The output shall be connected with display unit.

3) The meter shall include 25 feet of cable to connect with a remotely mounted display unit.

4) Unless indicated otherwise, the initial span adjustment of each transmitter shall be 0-120% of the scheduled maximum flow rate.

e. Accuracy:

1) The accuracy of each meter/transmitter assembly shall be ± 1.0% of flow rate reading over a range of 3-15 feet/second fluid velocity, with a repeatability of 0.1%. Accuracy at 1 foot/second shall be ± 2.0%.

f. Display Unit:

1) Pair with Display Unit described below.

g. BTU Meter:

1) Pair with BTU Meter described below.

h. Calibration:

1) Each meter shall be calibrated on a NIST traceable flow stand at 1, 8, and 15 FPS. Provide written documentation of calibration.

i. Installation Hardware

1) The flow meter shall be supplied with standard installation hardware, which shall include, but not be limited to, full port bronze ball valve, brass close nipple and weld-on carbon steel branch outlet.

j. Warranty:

1) Provide performance warranty of at least two years from the date of installation and startup. Warranty shall cover parts and labor for repair or replacement of the meter assembly. Performance during the warranty period shall satisfy the above-stated requirements for accuracy and repeatability.

k. Approved Manufacturers:

1) ABB, Onicon, Magmeter.

3. Display Unit:

a. General:

1) The display shall compatible with virtually any flow meter.

2) The display module shall provide a local indication of liquid flow rate and net totalized flow, along with associated engineering units (e.g., GPM/second and gallons).

3) House in a steel wall-mounted enclosure with a built-in user interface/display.

4) Display unit shall accept 4-20 mA pulse or contact closure flow signals. It shall also function as a network interface for two (2) additional analog rate inputs and one (1) additional totalizing pulse input.

5) It shall support BACnet communication protocols.

6) The display shall have two-line alphanumeric LCD displays of flow rate and flow total.

7) The display shall have non-volatile EEPROM memory that retains all program parameters and totalized values in the event of power loss.

8) Electrical Power Supply: 24VAC. 60Hz, 500mA max.

b. Approved Manufacturers:

1) Onicon, Yokogawa.

4. Airflow Measuring Stations:

a. In accordance with the requirements of LEED EQc1: Outdoor Air Delivery Monitoring, any AFMS used to measure outside air CFM shall have an accuracy of ±15% of the design minimum outdoor air flow rate (or better). The AFMS accuracy shall also comply with requirements outlined in the following paragraphs of this specification.

b. Duct Mounted Airflow Measuring Stations (AFMS) - Thermal Dispersion

1) Provide airflow/temperature measurement devices where indicated on the plans.

2) Each AFMS shall consist of one or more sensor probes and a single, remotely mounted, microprocessor-based transmitter capable of independently processing up to 16 independently wired sensor assemblies.

a) Each sensor assembly shall contain two individually wired, hermetically sealed bead-in-glass thermistors.

b) Thermistors shall be mounted in the sensor assembly using a marine-grade, waterproof epoxy. Thermistor leads shall be protected and not exposed to the environment.

c) Devices using chip-in-glass or diode-case chip thermistors are not acceptable.

d) Devices using less than two thermistors in each sensor assembly are not acceptable.

e) Devices using platinum wire RTDs are not acceptable.

f) Devices having electronic circuitry mounted in or at the sensor probe are not acceptable.

g) Pitot tubes and arrays are not acceptable.

h) Vortex shedding devices are not acceptable.

3) All Sensor Probes

a) Each sensor assembly shall independently determine the velocity and temperature at its measurement point.

b) Each sensor assembly shall be calibrated at a minimum of 16 airflow rates and 3 temperatures to standards that are traceable to the National Institute of Standards and Technology (NIST).

c) Airflow measuring station assembly accuracy shall be +/-2% of Reading over the entire operating airflow range. Temperature accuracy shall be +/-0.15° F between -20° F and 160° F.

d) The operating humidity range for each sensor probe shall be 0-99% RH (non-condensing).

e) Each sensor probe shall have an integral, UL listed, plenum rated cable and terminal plug for connection to the remotely mounted transmitter. A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter for each measurement location.

f) The number of probes shall be as recommended by the manufacturer to achieve the specified accuracy.

4) Duct and Plenum Probes

a) Probes shall be constructed of extruded, gold anodized, 6063 aluminum tube. All wires within the aluminum tube shall be Kynar coated.

b) Probe assembly mounting brackets shall be constructed of 304 stainless steel.

c) The operating airflow range shall be 0 to 5,000 FPM unless otherwise indicated on the plans.

5) Sensor Density

Area (sq.ft.)	Total # of Sensors Required
< 2	4
2 to < 4	6
4 to < 8	8
8 to < 16	12
≥ 16	16

6) Transmitters

a) The transmitter shall have an integral 16 character alphanumeric LCD display capable of simultaneously displaying individual airflow and temperature.

b) The transmitter shall be capable of field configuration and diagnostics using an on-board interface and LCD display.

c) The operating temperature range for the transmitter shall be -20° F to 120° F.

d) The transmitter shall be capable of communicating with other devices using one of the following interface options:

(1) Linear analog output signals for airflow and temperature: Field selectable, fuse protected and isolated, 0-10VDC/4-20mA (4-wire)

(2) RS-485: Field selectable BACnet-ARCNET, BACnet-MS/TP, Modbus-RTU or Johnson Controls N2-Bus. BACnet devices shall provide analog variables for airflow and temperature containing individual sensor airflow rate and temperature data.

(3) 10 Base-T Ethernet: Field selectable BACnet Ethernet, BACnet-IP, Modbus-TCP and TCP/IP. Provide dynamic link libraries and VBA functions to interface Ethernet devices to Microsoft Excel for remote monitoring of airflow and temperature using a Windows 2000 or Windows XP based PC.

(4) LonWorks Free Topology

c. Fan Inlet Airflow Measuring Stations - Differential Pressure:

1) Fan Inlet Measuring Station Pressure Sensors, Transmitters and Transducers:

a) Select for appropriate pressure range, fan type, inlet velocity, and airflow volume.

b) Transmitter features and minimum performance requirements shall be as follows:

(1) Combined Accuracy: ± 0.50%.
(2) Terminal Point Nonlinearity: ± 0.40%.
(3) Hysteresis: ± 0.02%.
(4) Non-repeatability: ± 0.05%.
(5) Compensation Range:

(a) Zero Shift: ±0.025% FS/°F.
(b) Span Shift: 0.025% FS/°F.

(6) Differential Overpressure: 5 psi proof and 25 psi burst pressure.
(7) Output signal: 0 to 10 VDC.

c) Each transducer shall be provided with an integral manual zeroing valve to allow for field calibration of the zero reference value without the need for shutting the operating system down.

d) System airflow (measured in CFM) shall be continuously displayed on an LCD display meter (0.5 inches high by 3.5 digits) located on the face of the air volume/velocity transducer control enclosure.

d. Mounting of fan inlet static pressure sensing elements shall be in accordance with manufacturer's published installation instructions to ensure accuracy of readings.

F. Current Measuring Devices:

1. Current Switches for Constant Speed Motors:

a. Digital device rated for amperage load of motor or device with split core design, adjustable high and low trip points, 600 VAC rms isolation, induced power from the monitored load, LED indicator lamps for output status and sensor power. The device shall sense overloading, belt-loss, and power failure with a single signal.

2. Current Switches for Motors Controlled by VFD:

a. Digital device rated for amperage load of motor or device with split core design, factory programmed to detect motor undercurrent conditions on variable or constant volume loads, self-calibrating, positive status indication, LED indicator lamps, 600 VAC rms isolation, induced power from the monitored load with NO output. The current sensor shall store the motor current operating parameters in non-volatile memory and have a pushbutton reset to clear the memory if the operating parameters change or the sensor is moved to another load. The device shall sense overloading, belt-loss, and power failure with a single signal. The sensor shall be mounted on the load side of variable frequency drives.

G. Occupancy Sensors:

1. Ceiling mounted, passive infrared, 360° coverage pattern, zero crossing circuitry, adjustable sensitivity and time delay (initial setting: Time delay - 5 minutes), integral isolated relay with normally open and normally closed outputs, LED indicator, five-year warranty, UL listed. TCC shall submit manufacturer supplied sensor layout drawing for shop drawing review. Provide full room coverage as recommended by manufacturer.

H. Combination Carbon Monoxide/Nitrogen Dioxide Sensors:

1. Solid-state gas sensor/transmitter for each gas, NEMA 1 gasketed enclosure, normal operating temperature 0-120°F, normal relative humidity operation 5-95%, ± 5% accuracy, and detection range of 0-200 ppm. Unit shall be have a replaceable sensor element.

2. Provide separate 4-20 mA output from the sensor to the FMCS system for each gas.

3. Install with spacing per manufacturer and OSHA requirements.

4. Unit shall be factory calibrated and shall be re-calibrated after installation per manufacturer's recommendations.

I. Carbon Dioxide Sensors:

1. Microprocessor based non-dispersive infrared sensor with range of 0 to 2,000 ppm CO2 with ± 100 ppm accuracy, maximum drift (compensated) of ± 5% full scale in five years, VOC software and hardware sensing, duct mounting where applicable, 0-10V dc or 4-20 mA output directly proportional to ppm, adjustable alarm limit, membrane filter, and terminal block. The diffusion gas chamber in the sensor shall incorporate a reflective light pipe or wave guide surrounded by a gas permeable membrane that prevents particulate contamination of the sensor. Unit shall have selectable IAQ mode with output signal and sum of CO2 and VOC levels.

J. Miscellaneous Devices:

1. Control Relays:

a. Form "C" contacts rated for the application with "push-to-test" contact transfer feature and an integral LED to indicate coil energization.

b. Mount all relays and power supplies in a NEMA 1 enclosure beside the FMCS panel or controlled device and clearly label their functions.

2. Thermostat and Sensor Enclosures:

a. Clear plastic guard with lock. Wire guard with tamperproof screws. Setpoint shall be adjustable with cover in place. Fasten to wall separately from thermostat. Provide guards in all corridors, gymnasiums, locker rooms, toilet rooms, assembly halls and as noted on the drawings.

3. Twist Timers:

a. Wall-mounted heavy duty, with rotary dial and face graduated in minutes or hours as noted. Unit shall fit behind standard "decorator" wall plate. Color of timer and face plate shall match remainder of project. Verify with Electrical Contractor. Provide wall plate and engraved plastic label indicating service.

b. Switch shall be rated for 20 amps at 125 volts (10 amps at 277 volts) and fit standard 2-1/2" deep electrical box.

c. Provide time cycle noted on the drawings or in the specifications; up to 12 hours.

d. Acceptable Manufacturers: Paragon SWD Series, Tork A500 Series, Intermatic FD Series, or Marktime Series 93.

2.23 CONDUIT

A. Conduit and Fittings: Refer to Electrical Section 26 05 33 for materials and sizing.

2.24 WIRE AND CABLE

A. Wire and Cable Materials: Refer to Electrical Section 26 05 13 for wire and cable materials.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. Verify that systems are ready to receive work. Beginning of installation means installer accepts existing conditions.

B. Install system and materials in accordance with manufacturer's instructions.

C. Drawings of the TCS and FMCS network are diagrammatic only. Any apparatus not shown but required to meet the intent of the project documents shall be furnished and installed without additional cost.

D. Install all operators, sensors, and control devices where accessible for service, adjustment, calibration, and repair. Do not install devices where blocked by piping or ductwork. Devices with manual reset or limit adjustments shall be installed below 6'-0" if practical to allow inspection without using a ladder.

E. Verify locations of wall-mounted devices (such as thermostats, temperature and humidity sensors, and other exposed sensors) with drawings and room details before installation. Coordinate mounting heights to be consistent with other wall-mounted devices. Maximum height above finished floor shall not exceed 48”. In accordance with the requirements of LEED EQc1: Outdoor Air Delivery Monitoring, install all wall-mounted CO2 sensors between 3 feet and 6 feet above the floor.

F. Provide valves over 3/4" size with position indicators and pilot positioners where sequenced with other controls.

G. Mount control panels adjacent to associated equipment on vibration-free walls or freestanding angle iron supports. One cabinet may accommodate more than one system in same equipment room.

H. After completion of installation, test and adjust control equipment.

I. Check calibration of instruments. Recalibrate or replace.

J. Furnish and install conduit, wire, and cable per the National Electric Code, unless noted otherwise in this section.

K. All controls associated with the proper operation of air handling units, pumps, or other mechanical equipment served by emergency power shall be connected to the emergency power system. Control components shall not be powered from the life safety branch of the emergency power system. Coordinate emergency power source connections with the Architect/Engineer.

L. All hardware, software, equipment, accessories, wiring (power and sensor), piping, relays, sensors, power supplies, transformers, and instrumentation required for a complete and operational FMCS system, but not shown on the electrical drawings, are the responsibility of the TCC.

M. Labels For Control Devices:

1. Provide labels indicating service of all control devices in panels and other locations.

2. Labels may be made with permanent marking pen in the control panels if clearly legible.

3. Use engraved labels for items outside panel such as outside air thermostats.

4. Labels are not required for room thermostats, damper actuators and other items where their function is obvious.

N. VFDs:

1. This project includes several variable frequency drives to control the flow of fans and/or pumps based on a control variable.

2. Verify output signal required, 4-20 mA or 0-10V dc, with the EC.

3. If VFD has a bypass feature, auxiliary contacts on the drive may not be used for motor status. A separate relay must be used to indicate motor rotation in either hand or auto positions.

4. If a separate current transmitter or switch is indicated for status, install this device between the VFD and the motor. In this case, the drive status may be connected to the auxiliary contacts in the VFD.

5. Some devices, such as low limits and fire alarm shutdown relays, must be hardwired to the fan motor. Make connections such that fan will shut down whether in hand or auto position if the unit has a bypass feature.

O. Airflow Stations:

1. The transmitter shall be installed at a location that is protected from weather, water, and vibration.

2. Mount transmitter where they can easily be read (36" to 66" above floor). Do not fasten transmitters directly to ductwork or compromise duct insulation.

3. The manufacturer's authorized representative shall visit the project site during construction prior to station installations to confirm all submitted sizes, mounting requirements and locations. Size adjustments shall be made at no additional cost. The representative shall meet on site with the TCC to support and train them on proper installation procedures and calibration.

4. Install labels at each sensor and transmitter identifying its service.

3.2 GRAPHIC DISPLAY

A. Create a customized graphic for each piece of equipment indicated on the itemized points list.

B. Components shall be arranged on graphic as installed in the field.

C. Include each graphic point listed in the itemized points list using real time data.

D. Provide a graphic representation of the following:

1. Where there are multiple buildings, color code the campus map by the systems serving that building. The building graphic shall be linked to the graphic for that building's systems.

2. Where there are multiple floors, provide color codes/designations for the areas served by each AHU and TAB by floor.

3. Where multiple AHUs serve one floor, color code the areas served by each AHU. The area shall be linked to the graphic for that area's AHU.

4. Provide an overall floor plan of each floor of the building color coded by zone linked to the TAB for that zone. The zone shall be linked to the graphic for that zone's TAB graphic.

5. Show the location of each thermostat on the floor plan.

6. Provide separate graphics showing the chilled and heating water system flow diagram. Show temperatures and flows on the flow diagram. Each piece of equipment shown on the flow diagram shall be linked to the graphic for that piece of equipment.

7. Provide a graphic showing the steam system flow diagram. Show pressures and flows on the flow diagram. Each piece of equipment shown on the flow diagram shall be linked to the graphic for that piece of equipment.

E. The FMCS shall include full graphic operator interface to display the following graphics as a minimum:

1. Home page to include a minimum of six critical points: Outside Air Temperature, Outside Air Relative Humidity, Enthalpy, KWH, KW, etc.

2. Graphic floor plans accurately depicting rooms, walls, hallways, and showing accurate locations of space sensors and major mechanical equipment.

3. Detailed graphics for each mechanical system including AHUs, ERUs, EFs, chillers, and boilers, as a minimum.

4. Access corresponding system drawings, technical literature, and sequences of operations directly from each system graphic.

F. The FMCS shall include individual graphical buttons to access the following data stored in PDF format:

1. Project control as-built documentation including all TCS drawings, diagrams and sequences of operation.

2. TCS Bill of Material for each system, e.g. AHU, RTU, FCU, boiler, etc.

3. Technical literature specification data sheets for all components listed in the TCS Bill of Material.

3.3 CONDUIT INSTALLATION

A. Conduit Sizing and Installation: Refer to Electrical Section 26 05 33 for execution and installation.

1. Thermostats/temperature sensors shall be installed in junction boxes, flush with the wall, and shall be coordinated for orientation with Architect/Engineer.

3.4 WIRE AND CABLE INSTALLATION

A. Wire and Cable Materials Installation: Refer to Electrical Section 26 05 13 for execution and installation.

B. Field Quality Control:

1. Inspect wire and cable for physical damage and proper connection.

2. Torque test conductor connections and terminations to manufacturer's recommended values.

3. Perform continuity test on all conductors.

4. Protection of cable from foreign materials:

a. It is the Contractor's responsibility to provide adequate physical protection to prevent foreign material application or contact with any cable type. Foreign material is defined as any material that would negatively impact the validity of the manufacturer's performance warranty. This includes, but is not limited, to overspray of paint (accidental or otherwise), drywall compound, or any other surface chemical, liquid or compound that could come in contact with the cable, cable jacket or cable termination components.

b. Overspray of paint on any cable, cable jacket or cable termination component will not be accepted. It shall be the Contractor's responsibility to replace any component containing overspray, in its entirety, at no additional cost to the project. Cleaning of the cables with harsh chemicals is not allowed. This requirement is regardless of the PASS/FAIL test results of the cable containing overspray. Should the manufacturer and warrantor of the structured cabling system desire to physically inspect the installed condition and certify the validity of the structured cabling system (via a signed and dated statement by an authorized representative of the structured cabling manufacturer), the Owner may, at their sole discretion, agree to accept said warranty in lieu of having the affected cables replaced. In the case of plenum cabling, in addition to the statement from the manufacturer, the Contractor shall also present to the Owner a letter from the local Authority Having Jurisdiction stating that they consider the plenum rating of the cable to be intact and acceptable.

C. Installation Schedule:

1. Conduit terminations to all devices installed in applications with rotating equipment, expansion/contraction or vibration shall be made with flexible metallic conduit, unless noted otherwise. Final terminations to exterior devices installed in damp or wet locations shall be made with liquidtight flexible metallic conduit. Terminations in hazardous areas, as defined in the National Electrical Code, shall be connected using flexible conduit rated for the environment.

3.5 FMCS INSTALLATION

A. Coordinate voltage and ampacity of all contacts, relays, and terminal connections of equipment being monitored or controlled. Voltage and ampacity shall be compatible with equipment voltage and be rated for full ampacity of wiring or overcurrent protection of circuit controlled.

B. Naming Conventions: Coordinate all point naming conventions with Owner standards. In the absence of Owner standards, naming conventions shall use equipment designations shown on plans.

3.6 COMMISSIONING

A. Upon completion of the installation, this Contractor shall load all system software and start up the system. This Contractor shall perform all necessary calibration, testing and de-bugging and perform all required operational checks to ensure that the system is functioning in full accordance with these specifications.

B. This Contractor shall perform tests to verify proper performance of components, routines, and points. Repeat tests until proper performance results. This testing shall include a point-by-point log to validate 100% of the input and output points of the FMCS system operation.

C. This Contractor shall prove that the controls network is functioning correctly and within acceptable bandwidth criteria and shall test the system with an approved protocol analysis tool. Provide a log and statistics summary showing that each channel is within acceptable parameters. Each channel shall be shown to have at least 25% spare capacity for future expansion.

D. Upon completion of the performance tests described above, repeat these tests, point by point, as described in the validation log above in the presence of Owner's Representative, as required. Properly schedule these tests so testing is complete at a time directed by the Owner's Representative. Do not delay tests so as to prevent delay of occupancy permits or building occupancy.

E. System Acceptance: Satisfactory completion is when this Contractor has performed successfully all the required testing to show performance compliance with the requirements of the Contract Documents to the satisfaction of the Owner's Representative. System acceptance shall be contingent upon completion and review of all corrected deficiencies.

3.7 PREPARATION FOR BALANCING

A. Verify that all dampers are in the position indicated by the controller (e.g., open, closed or modulating).

B. Check the calibration and setpoints of all controllers.

C. Check the locations of all thermostats and humidistats for potential erratic operation from outside influences such as sunlight, drafts, or cold walls.

D. Check that all sequences operate as specified. Verify that no simultaneous heating and cooling occurs, unless specified. Observe that heating cannot begin at TAB reheat terminals until the unit is at the minimum cfm.

E. Verify the operation of all interlock systems.

3.8 TEST AND BALANCE COORDINATION

A. The Contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.

B. The Contractor shall provide a minimum of four (4) hours training for the Balancing Contractor in the use of these tools.

C. In addition, the Contractor shall provide a qualified technician to assist in the test and balance process until the first 20 terminal units are balanced.

D. The tools used during the test and balance process shall be returned at the completion of the testing and balancing.

3.9 DEMONSTRATION AND ACCEPTANCE

A. At completion of installation, provide two days minimum instruction for operators. Demonstrate operation of all controls and systems. Describe the normal operation of all equipment.

3.10 TRAINING

A. On-Site:

1. After completion of commissioning, the manufacturer shall provide 8 hours of training on consecutive days for 4 Owner's representatives. The training course shall enable the Owner's representatives to perform Day-to-Day Operations as defined herein. A factory-trained instructor with experience in presenting the training material and the system programmer for this project shall perform the training.

B. Day-to-Day Operations - Training Description:

1. Proficiently operate the system.
2. Understand control system architecture and configuration.
3. Understand FMCS systems components.
4. Understand system operation, including FMCS system control and optimizing routines (algorithms).
5. Operate the workstation and peripherals.
6. Log-on and off the system.
7. Access graphics, point reports, and logs.
8. Adjust and change system setpoints, time schedules, and holiday schedules.
9. Recognize malfunctions of the system by observation of the printed copy and graphic visual signals.

10. Understand system drawings and Operation and Maintenance manual.
11. Understand the job layout and location of control components.
12. Access data from FMCS controllers and ASCs.
13. Operate portable operator's terminals.

C. Advanced Operations - Training Description:

1. Make and change graphics on the workstation.
2. Create, delete, and modify alarms, including annunciation and routing of these.
3. Create, delete and modify point trend logs and graph or print these both on and ad-hoc basis and at user-definable time intervals.
4. Create, delete, and modify reports.
5. Add, remove, and modify system's physical points.
6. Create, modify and delete programming.
7. Add panels when required.
8. Add operator interface stations.
9. Create, delete, and modify system displays, both graphic and others.
10. Perform FMCS system field checkout procedures.
11. Perform FMCS controller unit operation and maintenance procedures.
12. Perform workstation and peripheral operation and maintenance procedures.
13. Perform FMCS system diagnostic procedures.
14. Configure hardware including PC boards, switches, communication, and I/O points.
15. Maintain, calibrate, troubleshoot, diagnose, and repair hardware.
16. Adjust, calibrate, and replace system components.

D. System Management - Training Description:

1. Maintain software and prepare backups.
2. Interface with job-specific, third-party operator software.
3. Add new users and understand password security procedures.

E. Provide course outline and materials in accordance with the "SUBMITTALS" article in Part 1 of this section. The instructor(s) shall provide one copy of training material per student.

3.11 INSTALLATION OF SENSORS

A. Install sensors in accordance with the manufacturer's recommendations.

B. Mount sensors rigidly and adequately for the environment within which the sensor operates.

C. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.

D. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.

E. Averaging sensors and low limits shall be installed at the top of the assembly with the element on a slight downward incline away from the sensor making a serpentine pattern over the cross-sectional area with elements spaced not over 12" apart and within 6" of the top and bottom of the area.

F. All pipe-mounted temperature sensors shall be installed in immersion wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.

G. Install outdoor air temperature sensors on exterior of north wall, complete with sun shield at designated location approved by Architect/Engineer. TCC shall prime and paint the device enclosure. Color selection by Architect.

H. Install all wall-mounted CO2 sensors between 3 feet and 6 feet above the floor.

3.12 INSTALLATION OF FLOW METERS

A. Provide manufacturer's recommended lengths of straight piping upstream and downstream of the flow meter. Up to 30 diameters upstream of the flow meter may be required depending on the piping arrangement and flow meter type.

B. Maintain adequate pull/service space.

END OF SECTION

SECTION 23 09 13
INSTRUMENTATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Pressure Gauge.
B. Pressure Gauge Accessories.
C. Thermometers.
D. Test Plugs.
E. Static and Differential Airflow Pressure Gauges.

1.2 SUBMITTALS

A. Submit shop drawings per Section 23 05 00. Include list that indicates use, operating range, total range and location for manufactured components.

PART 2 - PRODUCTS

2.1 PRESSURE GAUGES

A. Gauges shall be 4-1/2" diameter with aluminum or stainless steel case with phosphor bronze bourdon tube, brass socket for air, steam, water or oil application, 1/4" or 1/2" bottom connection. Gauges shall be 1% full scale accurate with bronze brushed brass movement and adjustable pointer. Standard ranges to be either pressure or pressure and vacuum as required of application.

B. Acceptable Manufacturers: Ashcroft, Marsh, Marshalltown, Miljoco, Trerice, U.S. Gauge Figure 1901, Weiss, Weksler, Wika.

2.2 PRESSURE GAUGE ACCESSORIES

A. All pressure gauges shall have valves and pressure snubbers. All pressure gauges on steam shall have pigtail syphon.

B. Shutoff Valve: 1/4" ball valve as specified for each piping system.

C. Pressure snubber, brass with 1/4" connections, porous metal type.

2.3 THERMOMETERS

A. Dial Type:

1. 4-1/2" diameter, hermetically sealed case. Stainless steel case and stem. Accuracy of 1% full scale with external recalibrator.

2. Select thermometers for appropriate temperature range. Adjustable elbow joint with locking device to allow rotation of thermometer to any angle.

3. Stem lengths as required for application with minimum insertion of 2-1/2".

4. Thermometers for water, steam, or oil shall have brass or steel separable socket. Socket shall extend through insulation. Thermometers for air shall have an aluminum or brass duct flange.

5. Acceptable Manufacturer: Ashcroft, Marsh, Marshalltown, Miljoco, Tel-Tru, Trerice, U.S. Gauge, Weiss, Weksler, Wika.

B. Select scales to cover expected range of temperatures.

2.4 TEST PLUGS

A. Test Plug: 1/4" or 1/2" brass fitting and cap, with Nordel core for temperatures up to 275°F, for receiving 1/8" outside diameter pressure or temperature probe. Plugs shall be rated for zero leakage from vacuum to 500 psi.

B. Provide extended units for all plugs installed in insulated piping.

C. Test Kit: Carrying case, internally padded and fitted containing one 3-1/2" diameter pressure gauge with 0-100 psi range, one gauge adapter with 1/8" probes, two 1-1/2" dial thermometers with 0° to 220°F and -25°F to 125°F ranges and 5" stems.

D. Acceptable Manufacturers: Sisco, Flow Design, or Peterson Equipment.

2.5 STATIC AND DIFFERENTIAL AIRFLOW PRESSURE GAUGES

A. Diaphragm-activated gauge with 4-3/4" dial, cast aluminum case, sealed interior, designed to resist shock and vibration, and rated for 15 psig.

B. Accuracy shall be ± 3% of full scale maximum throughout entire range at 70°F.

C. Provide mounting brackets, probes, and shutoff valves required for proper installation.

D. The range and service shall be as required for application or as noted on the drawings.

E. Acceptable Manufacturers: Dwyer Magnehelic Series 2000, Marshalltown Instrument Series 85C.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install per manufacturer's instructions.

2. Coil and conceal excess capillary on remote element instruments.

3. Install gauges and thermometers in locations where they are easily read from normal operating level.

4. Do not install instrumentation when areas are under construction, except for required rough-in, taps, supports and test plugs.

B. Pressure Gauges:

1. Connect pressure gauges to suction and discharge side of all pumps.

2. Provide snubber for each pressure gauge.

3. Provide coil syphon for each pressure gauge connected to steam piping.

C. Thermometers:

1. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2" for installation of thermometer sockets.

2. Install thermometer sockets adjacent to control system thermostat, transmitter and sensor sockets.

3. Locate duct thermometers minimum 10 feet downstream of mixing dampers, coils, or other devices causing air turbulence.

END OF SECTION

SECTION 23 21 00
HYDRONIC PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Pipe and Pipe Fittings.
B. Valves.
C. Heating Water Piping System.
D. Geothermal Water Piping System.

1.2 QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body. Remanufactured valves are not acceptable.

B. Welding Materials, Procedures, and Operators: Conform to ASME Section 9, ANSI/AWS D1.1, and applicable state labor regulations.

1.3 SUBMITTALS

A. Submit product data under provisions of Section 23 05 00. Include data on pipe materials, fittings, valves, and accessories.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store and protect piping to prevent entrance of foreign matter into pipe and to prevent exterior corrosion.

B. Deliver and store valves in shipping containers with labeling in place.

1.5 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 23 05 00 for required hydronic systems electronic CAD drawings to be provided to Coordinating Contractor for inclusion into composite coordination drawings.

PART 2 - PRODUCTS

2.1 HEATING WATER
GEOTHERMAL WATER INTERIOR TO BUILDING

A. Design Pressure: 125 psig.
Maximum Design Temperature: 225ºF. (230ºF for mechanical couplings)

B. Piping - 2" and Under:

1. Tubing: Type L drawn temper seamless copper tube, ASTM B88.

2. Joints: Solder with Type 95-5 solder. 50-50 solder is not acceptable.

3. Fittings: Wrought copper solder joint, ASME B16.22.

C. Piping - 2-1/2" and Over:

1. Pipe: Standard weight black steel, beveled ends, ASTM A53, Type E or S, Grade B.

2. Joints: Butt-welded or flanged.

3. Fittings: Standard weight wrought steel, butt-welding type, ASTM A234, ASME B16.9.

4. Flanges: Class 150 forged steel, welding neck or slip-on, ASTM A181 or A105, Class 60, ASME B16.5 up to 24" and B16.47 above 24". ASME B16.1 for flanges mating with flat face equipment flanges.

D. Shutoff Valves:

1. Ball Valves:

a. BA-1: 3" and under, 150 psi saturated steam, 600 psi WOG, full port, screwed or solder ends (acceptable only if rated for soldering in line with 470°F melting point of lead-free solder), bronze body of a copper alloy containing less than 15% zinc, stainless steel ball and stem, Teflon seats and seals. Apollo #77C-140, Stockham #S-206 BR1-R, Milwaukee #BA-400, Watts, Nibco #585-70-66, National Utilities Co., RUB.

NOTES:

1) Provide extended shaft with operating handle of non-thermal conductive material and protective sleeve that allows operation of valve, adjustment of the packing, and adjustment of the memory stop without breaking the vapor seal or disturbing the insulation for all valves in insulated piping.

b. BA-1A: 2-1/2" and over: 150 psi saturated steam, 275 psi WOG ANSI Class, 150 psi standard port, ductile iron body, FPA fused stainless steel ball and trim, Teflon seats and seals. American Valve 4000D

NOTES:

1) Provide extended shaft for all valves in insulated piping.

E. Throttling Valves:

1. Globe Valves:

a. GL-1: 2" and under, 125 psi saturated steam, 300 psi WOG, screwed, bronze. Crane #7TF, Stockham #B22T, Walworth #95, Milwaukee #590, Hammond #IB413T, Watts #B-4010-T, NIBCO #T-235.

b. GL-2: 2-1/2" thru 10", 125 psi S @ 353ºF, 200 psi WOG @ 150ºF, flanged, iron body, bronze mounted. Crane #351, Hammond #IR116, Stockham #G-512, Walworth #906F, Milwaukee #F2981, Watts #F-501, NIBCO #F-718-B.

c. GL-5: 2" and under, 300 psi WOG, solder, bronze. Hammond #IB423, Stockham #B24T, Milwaukee #1590, Watts #B-4011-T, NIBCO #S-235.

2. Butterfly Valves:

a. BF-4:

1) 2-1/2" thru 6", 175 psi WOG, elastomers rated for 20ºF to 250ºF at 125 psig, fully lugged or grooved end, ductile or cast iron body (not in contact with fluid); bronze, aluminum-bronze or EPDM coated ductile iron disc; EPDM seat, stainless steel stem, extended neck, 175 psi bubble-tight, bi-directional dead-end shutoff without backing flange or nuts and with cap screws extending to centerline of valve body (for pipe extension without draining system), infinite position locking operator with memory stop up to 6" size. Cv of at least 1580 in

6" size. Victaulic #300, Center Line Series 200, Keystone #222, Watts #DBF-03-121-1P, NIBCO N200 Series or LD2000 Series, Milwaukee CL series, Hammond 5200 series.

F. Check Valves:

1. CK-1: 2" and under, 125 psi S @ 353ºF, 200 psi WOG @ 150ºF, screwed, bronze, horizontal swing. Crane #37, Hammond #IB904, Stockham #B319, Walworth #406, Milwaukee #509, Watts #B-5000, or NIBCO #T-413.

2. CK-4: 2" and under, 200 psi WOG @ 150ºF, solder, bronze, horizontal swing. Crane #1342, Hammond #IB912, Stockham #B309, Walworth #406SJ, Milwaukee #1509, Watts #B-5001, or NIBCO #S-413.

3. CK-13: 2-1/2" thru 12", 200# WOG, double disc wafer type, iron body, bronze or aluminum-bronze discs, 316SS shaft and spring, Viton, EPDM or BUNA-N, Cv of at least 700 in 6" size. Mueller Steam Specialty Co. #71-AHB-6-H, Stockham #WG-961, NIBCO W-920-W, Crane, Victaulic #716/716H.

G. Strainers:

1. ST-1: Bronze body, screwed ends, screwed cover, 150 psi S @ 350°F, 200 psi WOG @ 150°F. Armstrong #F4SC, Metraflex #TS, Mueller Steam Specialty Co. #351, Sarco #BT, Watts #777, NIBCO T-122.

2. ST-2: Cast iron body, 125 lb. flanged ends, bolted cover, 125 psi S @ 350°F, 175 psi WOG @ 150°F. Armstrong #A1FL, Metraflex #TF, Mueller Steam Specialty Co.#758, Sarco #CI-125, Watts #77F-D, Victaulic #732 or #W732, NIBCO F-721-A.

2.2 EQUIPMENT DRAINS AND OVERFLOWS

A. Steel Pipe: ASTM A53, Schedule 40 galvanized.

1. Fittings: Galvanized cast iron screwed drainage type, ASME B16.12.

2. Joints: Screwed.

3. Service: Not allowed on boiler drains and overflow.

B. Steel Pipe: ASTM A53. [for boiler drains only]

1. Pipe: Standard weight black steel, threaded and coupled, ASTM A53.

2. Joints: Screwed.

3. Fittings: Class 125 cast iron, ASTM A126, ASME B16.4.

C. Copper Tubing: DWV drawn temper seamless copper drainage tube, ASTM B306.

1. Fittings: ASME B16.23 cast brass, or ASME B16.29 solder wrought copper.

2. Joints: Solder with Type 95-5 solder. 50-50 solder is not acceptable.

D. Piping Under 1-1/4” Size:

1. In sizes where drainage type fittings are not available, tees with threaded caps to permit rodding are acceptable.

E. Shutoff Valves:

1. Ball Valves:

a. BA-1: 3" and under, 125 psi saturated steam, 600 psi WOG, full port, screwed or solder ends (acceptable only if rated for soldering in line with 470°F melting point of lead-free solder), bronze body of a copper alloy containing less than 15% zinc, stainless steel ball and trim, Teflon seats and seals. Apollo #77C-140, Stockham #S-206 BR1-R, Milwaukee #BA-400, Watts, Nibco #585-70-66, National Utilities Co., RUB.

NOTES:

1) Provide extended shaft for all valves in insulated piping.

2) Provide lock out trim for all valves opening to atmosphere installed in domestic water piping over 120°F, heating water piping over 120°F, steam, condensate, boiler feed water piping, compressed air piping and gasoline/kerosene piping, and as indicated on the drawings. Solid extended shaft is not required on valves with lock out trim.

b. BA-1A: 2-1/2" and 3", 150 psi saturated steam, 275 psi WOG ANSI Class, 150 psi standard port, carbon steel body stainless steel ball and trim, Teflon seats and seals. Apollo #88A-100, Nibco #F510-CS/66, Milwaukee #F90.

NOTES:

1) Provide extended shaft for all valves in insulated piping.

2) Provide lock out trim for all valves opening to atmosphere installed in domestic water piping over 120°F, heating water piping over 120°F, steam, condensate, boiler feed water piping, compressed air piping and gasoline/kerosene piping, and as indicated on the drawings. Solid extended shaft is not required on valves with lock out trim.

2.3 AIR VENTS

A. At end of main and other points where large volume of air may be trapped - Use 1/4" globe valve, angle type, 125 psi, Crane #89, attached to coupling in top of main, 1/4" discharge pipe turned down with cap.

B. On branch lines and small heating units - Use coin-operated air vent equal to B&G #4V, attached to 1/8" coupling in top of pipe. Install air vents on all coils and terminal heating units.

2.4 AUTOMATIC AIR VENTS

A. Low capacity automatic air vent (for bladder tank anti-thermosyphon loops). Maximum operating pressure and temperature of at least 240°F and 125 psi, 1/2" or 3/4" inlet. B&G #87, Armstrong, Spirotherm, or Watts.

B. High/low capacity automatic air vent (for air separator connection). Maximum operating pressure and temperature of at least 240°F and 125 psi, 3/4" inlet, 3/8" minimum outlet. B&G #107, Armstrong, Spirotherm, Taco, or Watts.

2.5 STRAINERS

A. Unless otherwise indicated, strainers shall be Y-pattern and have stainless steel screens with perforations as follows:

Pipe Size	
Water and Glycol/Water	20# mesh

B. Furnish pipe nipple with ball valve, threaded hose connection, and cap to blow down all strainer screens.

C. Use bronze body strainers in copper piping and iron body strainers in ferrous piping.

2.6 MAKE-UP WATER ACCESSORIES

A. Pressure Reducing Valve:

1. For water fill lines to hydronic systems.

2. Pressure reducing valve. Removable strainer, field adjustable discharge pressure, brass body, disc and seat, union with 1/2" or 3/4" NPT sweat connection, 125 psig maximum working pressure, 225°F maximum temperature.

3. Acceptable Manufacturers: Armstrong, Bell & Gossett, Conbraco, Thrush, Watts.

B. Relief Valve:

1. For water fill lines to hydronic systems.

2. Cast iron or bronze body, 1/2" or 3/4" screwed connections, 125 psig working pressure, 225°F maximum temperature. Minimum 500,000 Btuh capacity at 30 psig. Manual test lever.

3. Acceptable Manufacturers: Armstrong, Bell & Gossett, Conbraco, Watts.

C. Backflow Preventer:

1. Reduced pressure type as scheduled on the drawings.

2. Provide an air gap fitting and piping to drain.

3. If not indicated on the drawings, unit shall be same size as pipe.

4. Field test and tag units per manufacturer's instructions by a certified tester before initial operation.

2.7 SAFETY RELIEF VALVES

A. SRV-1 (Hydronic Heating Systems): Spring-loaded disc type with cast iron or bronze body, bronze or stainless steel disc, side outlet and lifting lever for maximum service of 125 psig at 250ºF. For relieving water during pressure fluctuations and in case of control failure. Capacities shall be ASME Section IV certified and labeled. Acceptable Manufacturers: Kunkle # 537, B&G, Conbraco, McDonnell & Miller, or Watts.

2.8 SUCTION DIFFUSER

A. Furnish and install on base mounted pumps with inlet size same as pipe size shown on the drawing.

B. In no case shall pressure drop exceed 3.0 psi.

C. Suction diffuser shall consist of angle body with inlet vanes and combination diffuser-strainer-orifice cylinder with 3/16" diameter openings for pump protection, gauge tappings, and blowdown connection. Orifice cylinder, with bronze or stainless steel strainer with free area at least 5 times cross section area of pump suction opening. Furnish adjustable foot to support weight of suction piping. Connect drain valve to blowdown connection. Provide 16 mesh bronze startup strainer. The startup strainer shall be removed after the system has been started, cleaned, and is operating under normal conditions, but before the system is turned over to the Owner. Hang the startup strainer on the piping near the pump after it is removed.

D. Acceptable Manufacturers: Amtrol, Armstrong, Bell & Gossett, Patterson, Taco, Wheatley, Victaulic.

2.9 BALANCING VALVE

A. Rated for 125 psi working pressure and 250ºF operating temperature, taps for determining flow with a portable meter, positive shutoff valves for each meter connection, memory feature, tight shutoff, and a permanent pressure drop between 1' and 2' water column at full flow with valve 100% open. Furnish with molded, removable insulation covers.

B. Provide a nomograph to determine flow from meter reading (and valve position on units which sense pressure across a valve). Graph shall extend below the specified minimum flow.

C. Furnish one meter kit equivalent to Bell & Gossett Model RO-5 meeting the following requirements:

1. Carrying case with handle.

2. Pressure gauge with 0-25 feet of head scale with 3.0% full scale accuracy.

3. High and low side hoses with 5 feet length and 250 psig pressure rating, equipped with shutoff valves, vent valves, and probes for insertion into pressure and temperature plugs.

D. Valves in copper piping shall be brass or bronze. Acceptable Manufacturers: Flow Design “Accusetter”, Presso “B+”, Armstrong "CVB", Bell & Gossett "Circuit Setter Plus", Griswold “Quickset”, Gerand “BALVALVE Venturi”, HCI “Terminator B”, NIBCO 1710 (S1710L), Tour&Anderson (STAD), Nexus Valve “UltraXB Orturi”, Victaulic 785.

E. Valves in ferrous piping 2" or smaller shall have threaded ends and steel, brass or bronze construction. Acceptable Manufacturers: Flow Design “Accusetter”, Presso “B+”, TA Hydronics “786-789”, Armstrong "CVB", Bell & Gossett "Circuit Setter Plus", Autoflow “AB”, Gerand “BALVALVE Venturi”, HCI “Terminator B”, NIBCO 1710 (T1710L), Nexus Valve “UltraXB Orturi”, Victaulic 787, or flow sensors specified in Section 23 09 00 with a specified throttling valve.

F. Balancing valves in ferrous piping over 2" size shall consist of flow sensors as specified in Section 23 09 00 combined with specified throttling valves.

G. Manufacturer shall size balancing valves for the scheduled flow rate. Flow rate shall be measurable on manufacturer's standard meters.

2.10 EXPANSION TANK

A. Bladder Type:

1. Tank shall be welded steel, ASME construction and stamped.

2. Tank shall be complete with heavy-duty replaceable butyl bladder, site glass, charging valve, lifting ring, drain tapping, and system connection.

3. 125 psig working pressure and 240ºF maximum operating temperature.

4. Acceptable Manufacturers: Thrush, Bell & Gossett, Armstrong, Watts, Wessels, Wheatley, Amtrol, Patterson.

2.11 BYPASS/SIDE STREAM FILTER

A. Cartridge filtration system rated for up to 50 gpm.

B. Filter vessel shall be 304 stainless steel and suitable for use up to 150 psi maximum operating pressure.

C. Vessel shall be equipped with an automatic air vent, manual air vent, and pressure gauge.

D. Filter shall be capable of removing 90% of all particles 5 microns and larger with each pass through the media.

E. Filter cartridge shall have a PVC core to prevent cartridge from collapse.

F. Filtration system shall be suitable for use up to 200°F.

G. System shall be provided with close coupled centrifugal pump with strainer capable of providing flow as scheduled on drawings.

H. Filtration system components shall be pre-piped and skid mounted as a single unit.

I. Mechanical Contractor shall provide and install shutoff valves on both up and downstream sides of filtration system, a check valve on suction side of pump between shutoff valve and pump, and drain piping to nearest trench drain.

J. Acceptable Manufacturers: PEP, Lenntech Filters, Parker Hannifin, United Filtration Systems, Lakos.

2.12 COALESCING TYPE COMBINATION AIR ELIMINATOR AND DIRT SEPARATOR

A. Coalescing type air eliminator and dirt separator shall be fabricated from steel and ASME constructed and certified for 125 psi working pressure and 270ºF operating temperature. Units 2-1/2 inches and smaller shall have threaded connections. Units 3 inches and larger shall have flanged connections.

B. Air elimination and dirt separation shall be by coalescing action by either:

1. Stainless steel PALL rings.

2. Copper tubes with continuous wound, permanently attached copper wire and followed by a separate continuous wound permanently affixed copper wire.

C. Provide unit with factory mounted air vent at the top of the air elimination chamber.

D. Provide brass flushing cock on the separator side to facilitate system fast-fill and to blow down impurities from the water surface within the separator.

E. Provide factory mounted blow-down valve on the unit bottom to allow for draining and cleaning.

F. Coalescing separators shall be as sized on the construction drawings, but in no case shall it have less than line size connections nor shall pressure drop exceed 1 psi at design flow. Include on submittal the pressure drop of each unit at its design flow rate.

G. Coalescing separators shall be equipped with removable cover to allow for removal, inspection and cleaning of the internal coalescing media.

H. Acceptable Manufacturers: Spirotherm VDN Series, Wessels WVA.

2.13 DRAIN VALVES AND BLOWDOWN VALVES

A. Drain valve and blowdown valve shall mean a shutoff valve as specified for the intended service with added 3/4" male hose thread outlet, cap, and retaining chain.

2.14 PROPYLENE GLYCOL - FOOD GRADE

A. Fill systems with a 25% solution by weight of water and industrially inhibited propylene glycol low temperature industrial heat transfer fluid with an expected life of at least 12 years in normal use. Water shall meet the glycol manufacturer's recommendations (generally < 25ppm chloride, sulfite, and hardness). Distilled, deionized, or reverse osmosis water is acceptable, as are pre-diluted solutions from the manufacturer.

B. Glycol shall be approved by Wisconsin DNR for geothermal applications.

C. All ingredients shall be FDA recognized as safe food additives. Fluid suitable for use from -28ºF to 250ºF.

D. Glycol shall pass ASTM D1384 (less than 0.5 mils annual penetration of all system metals). Glycol supplier shall provide a certificate of assurance.

E. For performance purposes a 50% solution by weight shall depress the freezing point to at least -34ºF. At 40ºF the solution shall have viscosity of not over 14 centipoises, thermal conductivity of at least 0.199 Btu/hr*ft*ºF, specific heat of at least 0.839 Btu/lbm*ºF, and specific gravity of at least 1.06. However, as described above the project requires a 25% solution by weight of propylene glycol.

F. Manufacturer shall offer a testing service to determine if inhibitor addition is needed.

G. Acceptable Manufacturer: Dow Chemical "Dowfrost", Interstate Chemical "P-323", Houghton Chemical "Safe-T-Therm

2.15 GLYCOL FEED SYSTEM

A. Package system complete with storage tank, pump(s) and controls with audio and visual alarm, designed to add glycol solution to a closed loop water system. System shall automatically maintain pressure in the piping system.

B. Provide cut-off and alarm to stop pump in case of low level or high pressure. Provide dry contact for alarm point to the DDC.

C. Complete with polyethylene storage tank and lid. Mount on floor above pumping assembly in a steel frame with legs. Lid shall be removable for filling and provide means for system relief valve outlet to be piped back to tank without removal of piping from relief valve or automatic air vent

D. Pumping system shall consist of a pump, starter, pressure tank with pressure control, pressure reducing valve, shutoff valve and pressure gauge. Refer to schedule for pump requirements.

E. Acceptable Manufacturer: Wessels GMP, Advantage Controls AGF, B&G GMU, Patterson.

2.16 LOCK OUT TRIM

A. Provide lock out trim for all quarter turn valves opening to atmosphere installed in heating water piping over 120°F and as indicated on the drawings.

PART 3 - EXECUTION

3.1 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. Connect to all equipment with flanges or unions.

D. After completion, fill, clean, and treat systems. Refer to Section 23 25 00 for treatment.

3.2 TESTING PIPING

A. Heating Water:
Geothermal Water (inside building):

1. Test pipes underground or in chases and walls before piping is concealed.

2. Complete testing before insulation is applied. If insulation is applied before pipe is tested and a leak ruins the insulation, replace all damaged insulation.

3. Test the pipe with 100 psig water pressure. Hold pressure for at least two hours.

4. Test to be witnessed by the Architect/Engineer or their representative, if requested by the Architect/Engineer.

3.3 CLEANING PIPING

A. Assembly:

1. Prior to assembly of pipe and piping components, remove all loose dirt, scale, oil and other foreign matter on internal or external surfaces by means consistent with good piping practice subject to approval of the Architect/Engineer. Blow chips and burrs out of pipe before assembly. Wipe cutting oil from internal and external surfaces.

2. During fabrication and assembly, remove slag and weld spatter from both internal and external joints by peening, chipping and wire brushing to the degree consistent with good piping practices.

3. Notify the Architect/Engineer prior to starting any post erection cleaning operation in time to allow witnessing the operation. Properly dispose of cleaning and flushing fluids.

4. Prior to blowing or flushing erected piping systems, disconnect all instrumentation and equipment, open wide all valves, control valves, and balance valves, and verify all strainer screens are in place.

B. Chemical Cleaning:

1. Flush pipe and components with clean water until all discharge from system is clean. Maintain minimum velocities at all points of 5 feet/second for 30 minutes. Flow shall be in same direction as when system is in normal operation. Discharge shall be from low points of pipes, ends of headers and as otherwise needed to flush entire system. After flushing, all residual water shall be drained and/or blown out.

2. Add 2 pounds of trisodium phosphate per 100 gallons of system capacity. Use an alternate chemical if discharge of trisodium phosphate is not permitted. Maintain 150°F in the system if possible. If heat is not available, use 3 pounds per 100 gallons.

3. Drain the system after circulating the chemical cleaner for six hours at 150°F, or 12 hours at a lower temperature. Refill. Test a water sample. Drain and fill again if excessive cleaning chemicals remain and until water appears clear.

4. After circulating the chemical cleaner for six hours at 150ºF, or 12 hours at less than 90ºF, connect fresh water to the system and discharge to a drain. Run circulating pumps and flush until discharge is clear water.

5. When system water is clear, remove, clean and replace all strainers.

6. Add chemical treatment as specified in Section 23 25 00.

7. Water samples may be taken by the Architect/Engineer to verify a clean system. If system is not clean, the entire process, including chemical treatment specified in Section 23 25 00, shall be repeated at the Contractor's expense.

8. Chemical cleaning applies to the following systems:

   a. Heating Water
   b. Geothermal Water

3.4 INSTALLATION

A. General Installation Requirements:

1. Route piping in orderly manner, straight, plumb, with consistent pitch, parallel to building structure, with minimum use of offsets and couplings. Provide only offsets required for needed headroom or clearance and needed flexibility in pipe system.

2. Install piping to conserve building space, and not interfere with other work.

3. Group piping whenever practical at common elevations.

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

5. Reducers are generally not shown. Where pipe sizes change at tee, the tee shall be the size of the largest pipe shown connecting to it. Where pipe sizes are not shown, the larger size in either direction shall continue through the fitting nearest to the indication of a smaller pipe size.

6. Install bell and spigot pipe with bells upstream.

7. Seal pipes passing through exterior walls with a wall seal per Section 23 05 29. Provide Schedule 40 galvanized sleeve at least 2 pipe sizes larger than the pipe.

8. Branch takeoffs shall be from the top side (if branch is two sizes smaller than main), or any angle from the horizontal plane to the top of piping.

B. Installation Requirements in Electrical Rooms:

1. Do not install piping or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the equipment plus its required clearance space.

C. Buried Piping:

1. Install thrust blocking and restraints on all buried piping at elbows and other changes in pipe direction.

D. Valves/Fittings and Accessories:

1. Provide chain operators for all valves over 2" size that are over 10'-0" above finished floor. Extend to 7'-0" above finished floor.

2. Provide valve position indicator on all valves 10’-0” or greater above finish floor and not located above ceiling.

3. Provide clearance for installation of insulation, and access to valves and fittings.

4. Provide access doors where valves are not exposed.

5. Where a manual balance valve is shown to be installed in series with a service (isolation) valve, separate balance and service (isolation) valves shall be installed.

6. Install balancing valves with the manufacturers recommended straight upstream and downstream diameters of pipe.

7. Prepare pipe, fittings, supports, and accessories for finish painting.

8. Install valves with stems upright or horizontal, not inverted, except install manual quarter turn valves in radiation cabinets and all butterfly valves with stems horizontal.

9. Provide shutoff valves and flanges or unions at all connections to equipment, traps, and items that require servicing.

10. Provide flanges or unions at all final connections to equipment, traps and valves.

11. Arrange piping and piping connections so equipment may be serviced or totally removed without disturbing piping beyond final connections and associated shutoff valves.

E. Underground Piping:

1. Lay all underground piping in trenches. Provide and operate pumping equipment to keep trenches free of water.

2. For all underground piping, provide a foundation 6" bedding layer of sand below the all pipe. Provide recessed areas for pipe bells and joints. After joints are made, any misalignment in elevation shall be corrected by tamping sand around the pipe. Backfill with sand in uniform layers not over 6" deep to the spring line of all underground pipes, and carefully compact each layer to 90 percent Proctor density. Backfill with sand up to 6" above pipe. Remaining backfill may be soil, unless under paving or buildings, in which case it shall be sand and compacted to 90 percent Proctor density.

3.5 PIPE ERECTION AND LAYING

A. Carefully inspect all pipe, fittings, valves, equipment and accessories prior to installation. Immediately reject and remove from the job any items which are unsuitable, cracked or otherwise defective.

B. All pipe, fittings, valves, equipment and accessories shall have factory-applied markings, stampings, or nameplates sufficient to determine their conformance with specified requirements.

C. Exercise care at every stage of storage, handling, laying and erecting to prevent entry of foreign matter into piping, fittings, valves, equipment and accessories. Do not erect or install any unclean item.

D. During construction, until system is fully operational, keep all openings in piping and equipment closed at all times except when actual work is being performed on that item. Closures shall be plugs, caps, blind flanges or other items designed for this purpose.

E. Change direction of pipes only with fittings or pipe bends. Change size only with fittings. Do not use miter fittings, face or flush bushings, or street elbows. **2-1/2" and larger fittings shall be long radius type**, unless otherwise shown on the drawings or specified. Construct welded elbows of angles not available as standard fittings by cutting and welding standard elbows to form smooth, long radius fittings.

F. Use full and double lengths of pipe wherever possible.

G. Unless otherwise indicated, install all inlet and outlet piping, including shutoff valves and strainers, to coils, pumps and other equipment at line size with reduction in size being made only at control valve or pump.

H. Cut all pipe to exact measurement and install without springing or forcing except in the case of expansion loops where cold springing is indicated on the drawings.

I. Do not create, even temporarily, undue loads, forces or strains on valves, equipment or building elements.

3.6 DRAINING AND VENTING

A. Unless otherwise indicated on the drawings, all horizontal pipes, including branches, shall pitch 1" in 40 feet to low points for complete drainage, removal of condensate, and venting.

B. Provide drain valves at all low points of water piping systems or where indicated on drawings for complete or sectionalized draining. Drain valves are defined above.

C. Use eccentric reducing fittings on horizontal runs when changing size for proper drainage and venting. Install all liquid lines with top of pipe and eccentric reducers in a continuous line.

D. Provide air vents at all high points and wherever else required for elimination of air in all water piping systems. Do not use automatic air vents in glycol systems unless they are piped to the fill tank.

E. Air vents shall be in accessible locations. If needed to trap and vent air in a remote location, a 1/8" pipe shall connect the tapping location to a venting device in an accessible location.

F. All vent and drain piping shall be of same materials and construction as the service involved.

3.7 BRANCH CONNECTIONS

A. Make branch connections with standard tee or cross fittings of the type required for the service unless otherwise specified herein or detailed on the drawings.

B. At the option of the Contractor, branch connections from headers and mains may be cut into black steel pipe using forged weld-on fittings.

C. Use of forged weld-on fittings is also limited as follows:

1. Must have at least same pressure rating as the main.
2. Header or main must be 2-1/2" or over.
3. Branch line is at least two pipe sizes under header or main size.

3.8 JOINING OF PIPE

A. Threaded Joints:

1. Ream pipe ends and remove all burrs and chips.
2. Protect plated pipe and valve bodies from wrench marks when making up joints.
3. Apply Teflon tape to male threads.

B. Flanged Joints:

1. Bronze flanges shall conform to B16.24 and ductile iron flanges to B16.42. Steel flanges shall be raised face except when bolted to flat face cast iron flange.

2. Bolting shall be ASTM A307 Grade B with bolts and heavy hexagonal nuts conforming to ASME B18.2.1 and B18.2.2.

3. Torque bolts in at least three passes, tightening to 1/3, 2/3, and final torque in a cross pattern with an indicating torque wrench for equal tension in all bolts.

4. Gaskets for flat face flanges shall be full-face type. Gaskets for raised faced flanges shall conform to requirements for "Group I gaskets" in ASME B16.5. All gaskets shall conform to ASME B16.21. Unless otherwise specified, gaskets shall meet the following requirements:

   a. Gasket material and thickness approved by manufacturer for intended service, chemical compatibility, pipe system test pressure, and operating temperature range.

   b. Maximum pressure rating of at least 250 psig.

   c. Minimum temperature rating: -10°F.

   d. Maximum temperature rating of at least 170°F for water and glycol solution systems operating 140°F and less.

   e. Maximum temperature rating of at least 250°F for water and glycol solution systems operating above 140°F and up to 180°F.

C. Solder Joints:

1. Make up joints with 95% tin and 5% antimony (95-5) solder conforming to ASTM B32 Grade 95TA. Cut copper tubing ends perfectly square and remove all burrs inside and outside. Thoroughly clean sockets of fittings and ends of tubing to remove all oxide, dirt and grease just prior to soldering. Apply flux evenly, but sparingly, to all surfaces to be joined. Heat joints uniformly to proper soldering temperature so solder flows to all mated surfaces. Wipe excess solder, leaving a uniform fillet around cup of fitting.

2. Flux shall be non-acid type conforming to ASTM B813.

3. Solder end valves may be installed directly in the piping system if the entire valve is suitable for use with 470ºF melting point solder. Remove composition discs and all seals during soldering if not suitable for 470ºF.

D. Welded Joints:

1. Welding of all pipe joints, both as to procedures and qualification of welders, shall be in accordance with Section IX, ASME "Boiler & Pressure Vessel Code" unless local codes take precedence.

2. Furnish certificates qualifying each welder to the Owner's Representative prior to start of work.

3. The Owner's Representative reserves the right to require qualifying demonstration, at the Contractor's expense, of any welders assigned to the job.

4. Ends of pipe and fittings to be joined by butt-welding shall be beveled, cleaned to bare metal and internal diameters aligned before tack welding.

5. Single-welded butt joints may be employed with or without the use of backing rings in all sizes. Where backing rings are not used on pumped pressurized systems, the root side of the weld shall either be chipped or ground flush with the piping wall. For services such as vents, overflows, and gravity drains, the backing ring may be eliminated, and the root of the weld need not be chipped or ground. Backing rings shall be of the material being welded.

END OF SECTION

SECTION 23 21 23
HVAC PUMPS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. All pumps except where integral with a manufactured piece of equipment.
B. Pump controls where self-contained.

1.2 SUBMITTALS

A. Submit shop drawings under provisions of Section 23 05 00.

B. Submit certified pump performance curves with pump and system operating point plotted. Include NPSH curve when applicable.

C. Pumps with motors operating above the RPM the pump curves are based on shall have impellers trimmed to deliver GPM and head scheduled.

D. Submit motor data indicating compliance with Section 23 05 13.

PART 2 - PRODUCTS

2.1 PUMPS - GENERAL

A. Statically and dynamically balance rotating parts.

B. Construction shall permit complete servicing without breaking piping or motor connections.

C. Pumps shall operate at 1750 rpm unless specified otherwise.

D. Pump connections shall be flanged, whenever available.

E. Heating pumps shall be suitable for 225ºF water.

F. Motors shall comply with Section 23 05 13.

G. Pump impellers shall not have smaller diameters than those scheduled. The inlet and discharge pipe sizes shall also meet or exceed the scheduled pump.

2.2 IN-LINE PUMP

A. Type: Centrifugal, single stage, close coupled in-line, back pullout design, suitable for horizontal or vertical operation.

B. Casing: Cast iron, rated for greater of 125 psior 1.5 times actual working discharge pressure, flanged suction and discharge with gauge ports.

C. Impeller: Bronze or stainless steel, fully enclosed, dynamically balanced, keyed to shaft and secured with locknut.

D. Shaft: Steel or stainless steel.

E. Seals: Carbon rotating against a stationary ceramic seat.

F. Acceptable Manufacturers: Bell & Gossett, Grundfos/Peerless/PACO.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install all products per manufacturer's recommendations.

2. Support piping adjacent to pumps so that no weight is carried by pump casings. Provide supports under elbows on 4" and larger pump suction and discharge pipes. Allow a minimum of 18" clearance for removal of suction diffuser.

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

4. For pumps not powered by a VFD, trim or order new impeller to meet maximum operating conditions. Coordinate final trimmed diameter with Testing, Adjusting, and Balancing Contractor.

5. Install on vibration isolators as scheduled on drawings.

B. In-Line Pumps:

1. Support in-line pumps individually so there is no strain on the piping. Install with a minimum of five diameters of straight pipe on pump suction and discharge.

END OF SECTION

SECTION 23 25 00
CHEMICAL (WATER) TREATMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Treatment for Closed Systems (Water).
B. Treatment for Closed Systems (Glycol).
C. Chemical Feed Equipment.

1.2 SUBMITTALS

A. Submit shop drawings under provisions of Section 23 05 00.

B. Include system schematics, equipment locations, and controls schematics.

C. Submit product data indicating chemicals and equipment.

D. Submit manufacturer's installation instructions.

E. Submit reports indicating start-up of treatment systems is completed and operating properly. Include reports indicating analysis of system water after cleaning and after treatment.

1.3 EXTRA STOCK

A. Provide clean cartridges or bags in all bypass (pot) feeders with filters.

B. Provide two complete sets of replacement cartridges or filters for each bypass (pot) feeder with filters and sidestream filter installed. Deliver to Owner at job site.

1.4 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data.

B. Include data on pumps and other equipment including spare parts lists, procedures, and treatment programs.

C. Include step-by-step instructions on test procedures including target concentrations and test frequencies.

D. Include list of treatment chemicals and the MSDS for all chemicals.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the products specified in this section with minimum five years documented experience. Company shall have local representatives with water analysis laboratories and full time service personnel.

1.6 REGULATORY REQUIREMENTS

A. Conform to all applicable codes and regulations for addition of non-potable chemicals to building mechanical systems, and for discharge to public sewage systems.

B. Provide only chemicals approved for use and disposal by local authorities. Contact the Architect/Engineer if any specified chemicals are prohibited.

1.7 MAINTENANCE SERVICE

A. Provide the following services to assist the owner in setting up and maintaining chemical treatment systems for one year from Date of Substantial Completion:

1. Provide technical service visits to perform field inspections and make water analysis on site. Visits shall be twice annually for closed systems and monthly for steam and cooling tower systems. For cooling tower systems, monthly testing shall have dipslide culture counts, and quarterly water samples shall be sent to a CDC Elite lab for culturing to establish baseline total organism and Legionella counts. Detail findings in writing on proper practices, chemical treating requirements, and corrective actions needed. Submit copies of the field service report after each visit to the Owner and to the Mechanical Contractor. Any problems related to the operation of the chemical treatment program shall be reported to the Architect/Engineer.

2. Provide laboratory and technical assistance services for warranty period.

3. Include one (1) hour training course for operating personnel, instructing them on installation, care, maintenance, testing, and operation of water treatment systems. Arrange course at start-up of systems.

4. Provide on-site inspections of equipment during scheduled or emergency shutdown to properly evaluate success of water treatment program, and make recommendations in writing based upon these inspections.

5. Provide sufficient chemicals for treatment and testing during warranty period.

B. The Chemical Treatment Subcontractor shall be responsible for assisting the Mechanical Contractor by adding the chemical solutions required for cleaning each piping system. During the remainder of the warranty period, the Chemical Treatment Subcontractor will be responsible for adding chemicals and doing other work related to the operation of system such as boiler blowdown. The Chemical Treatment Contractor shall make periodic tests of the chemical treatment program as called for above and recommend changes to Owner when needed.

1.8 WATER ANALYSIS

A. Sample feedwater to determine appropriate chemical treatment. Contact the Architect/Engineer if test indicates treatment required is different than that specified.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Nalco.
B. Betz.
C. America's Best Water Treaters.
D. H-O-H Chemicals, Inc.
E. Industrial Water Management.
F. Garratt-Callahan Company.
G. Lakeland Chemical Specialties, Inc.
H. Iowa Water Management Corp.
I. Butler Chemical Company.
J. Eldon Water.
K. ChemTreat.
L. Watertech of America
M. Earthwise Environmental, Inc.
N. Rhomar Water Management, Inc.

2.2 MATERIALS

A. Closed System Treatment (Water):

1. Provide one bypass feeder on each system. Install inlet, outlet and drain valves, and necessary piping.

2. Provide a 3/4" water meter in the domestic cold water line that provides makeup water to steam systems.

3. Provide coupon rack around main system pumps for all systems.

4. Proprietary blend containing the following items:

a. Corrosion Inhibitors for Water Systems Operating Above 145°F: Sodium nitrite-borax or molybdate with added inhibitors such as mercaptobenzothiazole, sodium tolytriazole, or phenyltriazole to protect copper and brass and minimize dielectric pitting of steel. Maintain 1,000 ppm nitrite or 100 ppm molybdate. Adjust borax content to keep correct pH for type of system (mainly steel or mainly copper).

b. Corrosion Inhibitors for Chilled Water Systems and Heating Systems operating at ≤145°F: Sodium molybdate with added inhibitors such as mercaptobenzothiazole, sodium tolytriazole, or phenyltriazole to protect copper and brass and minimize dielectric pitting of steel. Maintain 50 ppm molybdate. Adjust borax content to keep correct pH for type of system (mainly steel or mainly copper).

c. Scale Inhibitor: Organic phosphonates such as aminomethylene-phosphonate; phosphonates such as hydroxyethylidenediphosphonate or polyamino-substituted phosphonates; or synthetic polymers such as low-molecular-weight polyacrylates, poly-methacrylates and polyacrylanides. Inorganic phosphates are not acceptable. Maintain residual concentration as recommended by the manufacturer.

B. Closed System Treatment (Glycol):

1. The specified glycols contain initial charge of corrosion inhibitors, however, the pH after installation must be checked and adjusted to maintain between 8.0 and 10.0 using inhibitors recommended by the manufacturer (normally dipotassium phosphate).

2.3 EQUIPMENT

A. Bypass (Pot) Feeder: 5.0 gal; quick-opening cap with 3-1/2” minimum diameter opening and opening wrench, legs to raise fill cap to 30” to 36”, ASME rated, drain valve, air cock, working pressure of 200 psig at 200°F, 20 to 25 micron cartridge or bag filter. Acceptable Manufacturers: Griswold, Vector Industries, J.L. Wingert, or Neptune.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install bypass (pot) feeder with top approximately 36” above the floor.

C. Coordinate with Contractor to provide temporary metering capabilities during system fill to determine overall system volume.

D. For systems containing glycol, carefully review the glycol manufacturer's water requirements and coordinate to provide system cleaning, flushing, and initial fill with the proper quality of water conforming to the manufacturer's and these specifications.

3.2 CLOSED-LOOP HYDRONIC SYSTEM WATER QUALITY STANDARDS

A. Review equipment manufacturer's water quality standard to ensure water quality is sufficient to meet their warranty requirements as well as to ensure peak heat transfer efficiency. Contractor shall maintain hydronic systems within the more stringent of either the equipment manufacturer's requirements or those listed below:

Measured Value	Multi-Metal Systems with Aluminum	Multi-Metal Systems with Stainless Steel	Multi-Metal Systems with Copper
pH Range	6.5 – 8.5	6.5 – 8.5	9.0 – 10.0
Alkalinity as $CaCO_3$	100 – 500 mg/l	100 – 500 mg/l	100 – 500 mg/l
Hardness as $CaCO_3$*	100 – 500 mg/l	100 – 500 mg/l	100 – 500 mg/l
Suspended Solids	< 10 mg/l	< 10 mg/l	< 10 mg/l
Dissolved Solids	< 1,000 mg/l	< 1,000 mg/l	< 1,000 mg/l
Chlorides	< 150 mg/l	< 150 mg/l	< 150 mg/l
Iron	< 5.0 mg/l	< 5.0 mg/l	< 5.0 mg/l
Manganese	< 0.4 mg/l	< 0.4 mg/l	< 0.4 mg/l
Nitrate	< 100 mg/l	< 100 mg/l	< 100 mg/l
Sulfate	< 200 mg/l	< 200 mg/l	< 200 mg/l
Ammonia	< 5.0 mg/l	< 5.0 mg/l	< 5.0 mg/l
Free Copper	< 0.10 mg/l	< 0.10 mg/l	< 0.10 mg/l
Free Aluminum	< 3.0 mg/l		

* Minimum hardness only applies to softened water. If water from rivers or lakes is below 100 mg/l, remineralizing is not required.

B. Submit an independent third-party test report for each chemically treated closed-loop system showing compliance with all measured values shown in the above table as part of project closeout documentation.

END OF SECTION

SECTION 23 31 00
DUCTWORK

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Galvanized Ductwork
B. Ductwork Reinforcement
C. Ductwork Sealants
D. Rectangular Ductwork - Single Wall
E. Round and Flat Oval Ductwork - Single Wall
F. Exposed Ductwork (Rectangular, Round, or Oval)
G. Flexible Duct
H. Grease Exhaust Duct
I. Leakage Testing
J. Ductwork Penetrations
K. Duct Cleaning
L. Painting

1.2 SUBMITTALS

A. Submit shop drawings per Section 23 05 00.

B. Submit duct fabrication standards in compliance with SMACNA and these specifications. Clearly indicate metal gauges, reinforcement, and joining methods intended for use for each pressure classification. Furnish details of all common duct fittings and joint connections to be used on this project.

C. The Architect/Engineer may require field verification of sheet metal gauges and reinforcing to verify compliance with these specifications. At the request of the Architect/Engineer, the contractor shall remove a sample of the duct for verification. The contractor shall repair as needed.

1.3 DEFINITIONS

A. Duct Sizes shown on drawings are inside clear dimensions. Maintain clear dimensions inside any lining.

B. Transitions are generally not shown in single-line ductwork. Where sizes change at a divided flow fitting, the larger size shall continue through the fitting.

1.4 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 23 05 00 for required duct systems electronic CAD drawings to be provided to Coordinating Contractor for inclusion into composite coordination drawings.

B. Duct drawings shall be at 1/4" minimum scale complete with the following information:

1. Actual duct routing, ductwork fittings, actual sheet metal dimensions including insulation liner and wrap, duct hanger and support types, ductwork accessories, etc. with lengths and weights noted.

2. Differentiate ducts that are lined or wrapped. Include insulation thickness, type of insulation, and acoustical lagging.

3. Location and size of all duct access doors.

4. Room names and numbers, ceiling types, and ceiling heights.

5. Indicate location of all beams, bar joists, etc. along with bottom of steel elevations for each member.

C. IMEG will provide electronic file copies of ventilation drawings for contractor's use if the contractor signs and returns an "Electronic File Transfer" waiver provided by IMEG. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings. Architectural plans will need to be obtained from the Architect.

PART 2 - PRODUCTS

2.1 GALVANIZED DUCTWORK

A. General Requirements:

1. Duct and reinforcement materials shall conform to ASTM A653 and A924.

2. Interior Ductwork and reinforcements: G60 galvanized (0.60 ounces per square foot total zinc coating for two sides per ASTM A90) unless noted otherwise.

3. Exterior Ductwork: G90 galvanized (0.90 ounces per square foot total zinc coating for two sides per ASTM A90) unless noted otherwise. G60 is not acceptable for exterior use.

4. Ductwork reinforcement shall be of galvanized steel.

5. Ductwork supports shall be of galvanized or painted steel. Slip cable hangers are acceptable. Acceptable manufacturers are Gripple, Ductmate, Duro Dyne, or Architect/Engineer approved.

6. All fasteners shall be galvanized or cadmium plated.

2.2 DUCTWORK REINFORCEMENT

A. General Requirements:

1. All reinforcement shall be external to the duct except that tie rods may be used with the following limitations.

a. Ducts must be over 18" wide.

b. Duct dimensions must be increased 2" in one dimension (h or w) for each row of tie rods installed.

c. Tie rods must not exceed 1/2" diameter.

d. Manufacturer of tie rod system must certify pressure classifications of various arrangements, and this must be in the shop drawings.

2.3 DUCTWORK SEALANTS

A. One part joint sealers shall be water-based mastic systems that meet the following requirements: maximum 48-hour cure time, service temperature of -20°F to +175°F, resistant to mold, mildew and water, flame spread rating below 25 and smoke-developed rating below 50 when tested in accordance with ASTM E84, suitable for all SMACNA seal classes and pressure classes. Mastic used to seal flexible ductwork shall be marked UL 181B-M.

B. Two-part joint sealers shall consist of a minimum 3" wide mineral-gypsum compound impregnated fiber tape and a liquid sealant. Sealant system shall meet the following requirements: maximum 48-hour cure time, service temperature of 0°F to 200°F, resistant to mold, mildew, and water, flame spread rating below 25 and smoke developed rating below 50 when tested in accordance with ASTM E84, suitable for all SMACNA seal classes and pressure classes.

C. Pressure sensitive tape used for sealing ductwork shall be minimum 2.5-inch wide, listed and marked UL 181A-P, having minimum 60 oz/inch peel adhesion to steel, and service temperature range from -20°F to +250°F.

D. Joint sealers shall meet the volatile organic compound (VOC) limits of U.S. Green Building Council LEED credit EQ 4.1, Low-Emitting Materials - Adhesives & Sealants (follow the latest edition at the time of bidding or as referenced in these specifications).

E. Where pressure sensitive tape is called for on drawings and specifications for sealing flexible ductwork, tape shall be minimum 2.5-inch wide, UL 181 B-FX listed, and marked tape having minimum 60 oz/inch peel adhesion to steel and service temperature range from -20°F to +250°F. Acceptable manufacturers include: Venture Tape 1581A, Compac #340, Scotch Foil Tape 3326, Polyken 339.

2.4 RECTANGULAR DUCT - SINGLE WALL

A. General Requirements:

1. All ductwork gauges and reinforcements shall be as listed in SMACNA Duct Construction Standards Chapter 2. Where necessary to fit in confined spaces, furnish heaviest duct gauge and least space consuming reinforcement.

2. Transitions shall not exceed the angles in Figure 4-7.

B. Exceptions and modifications to the 2005 HVAC Duct Construction Standards are:

1. All ducts shall be cross-broken or beaded.

2. Turning vanes shall be used in all 90° mitered elbows, unless clearly noted otherwise on the drawings. Vanes shall be as follows:

a. Type 1:

1) **Description**: Single wall type with 22-gauge (0.029") or heavier vanes, 3-1/4" blade spacing, and 4" to 4-1/2" radius. Vanes hemmed if recommended by runner manufacturer. Runners shall have extra long locking tabs. C-value independently tested at below 0.26. EZ Rail II by Sheet Metal Connectors or equal.

2) **Usage**: Limited to 3,000 fpm and vane lengths 36" and under.

b. Type 2:

1) **Description**: Double wall type with 3-1/4" blade spacing, 4-1/2" radius, 24-gauge minimum, and SMACNA Type 1 runners. C-value below 0.27.

2) **Usage**: No limits other than imposed by the manufacturer. Provide intermediate support for vanes over 48" long.

c. Turning vanes shall operate quietly. Repair or replace vanes that rattle or flutter.

d. Runners must be installed at a 45° angle. Elbows with different size inlet and outlet must be radius type.

e. Omitting every other vane is prohibited.

3. Where smooth radius rectangular elbows are shown, they shall be constructed per SMACNA Figure 4-2. Type RE1 shall be constructed with a centerline duct radius R/W of 1.0. Where shown on drawings, Type RE3 elbows with 3 vanes shall be used with centerline duct radius R/W of 0.6 (SMACNA r/W=0.1). RE1 or RE3 elbows may be used where mitered elbows are shown if space permits. **Mitered elbows (with or without turning vanes) may not be substituted for radius elbows.** Do not make branch takeoffs within 4 duct diameters on the side of the duct downstream from the inside radius of radius elbows.

4. Rectangular branch and tee connections in ducts over 1" pressure class shall be 45° entry type per Figs. 4-5 and 4-6. Rectangular straight taps are not acceptable above 1" pressure class.

5. Bellmouth fittings shown on return duct inlets shall expand at a 60-degree total angle horizontally and vertically (space permitting) and have length of at least 25% of the smallest duct dimension.

6. Round taps off rectangular unlined ducts shall be flanged conical or bellmouth type (equal to Buckley Bellmouth or Sheet Metal Connectors E-Z Tap), or 45° rectangular with transition to round (equal to Sheet Metal Connectors Inc. High Efficiency Takeoff). Straight taps are acceptable if pressure class is 1" or less, round duct is 12" diameter or less, and the tap is not located between fans and TAB devices.

7. Duct offsets shall be constructed as shown on drawings. Additional offsets required in the field shall be formed of mitered elbows without turning vanes for offsets up to 30° maximum angle in accordance with SMACNA offset Type 2. Offsets of greater than 30° angle shall be formed of radius elbows with centerline radius R/W=1.0 or greater. SMACNA Type 1 offsets are not permitted.

8. All lined duct shall utilize dovetail joints where round or conical taps occur. The dovetail joints shall extend past the liner before being folded over.

9. Cushion heads are acceptable only downstream of TAB devices in ducts up to ± 2" pressure class, and must be less than 6" in length.

10. Slide-on flanged transverse joint systems are acceptable provided they are a manufactured product that has been tested for conformance with Chapter 2 of the SMACNA HVAC Duct Construction Standards for sheet and joint deflection at the specified pressure class.

a. Apply sealant to all inside corners. Holes at corners are not acceptable.

b. Acceptable Manufacturers: Ductmate Industries - 25/35/45, Nexus, Mez, or WDCI. Other manufacturers must submit test data and fabrication standards and receive Architect/Engineer's approval before any fabrication begins.

11. Formed-on flanged transverse joint systems are acceptable provided they are a manufactured product that has been tested for conformance with Chapter 2 of the SMACNA HVAC Duct Construction Standards for sheet and joint deflection at the specified pressure class.

a. Apply sealant to all inside corners. Holes at corners are not acceptable.

b. Flanges shall be 24-gauge minimum (not 26 gauge).

c. Acceptable Manufacturers: Lockformer TDC, TDF, United McGill, or Sheet Metal Connectors. Other manufacturers must submit test data and fabrication standards and receive Architect/Engineer's approval before any fabrication begins.

2.5 ROUND AND FLAT OVAL DUCTWORK - SINGLE WALL

A. Conform to applicable portions of Rectangular Duct Section. Round or flat oval ductwork may be substituted for rectangular ductwork where approved by the Architect/Engineer. The spiral seam ductwork shall meet the standards set forth in this specification. The ductwork shall meet or exceed the specified cross-sectional area and insulation requirements. The substitution shall be coordinated with all other trades prior to installation.

B. Snap lock seams are not permitted.

C. Flat oval duct in negative pressure applications shall have flat sides reinforced as required for rectangular ducts of the same gauge with dimensions equal to the flat span of the oval duct.

D. 90° elbows shall be smooth radius or have a minimum of five sections with mitered joints and R/D of at least 1.5.

E. Duct and fittings shall meet the required minimum gauges listed in chapter 3 of the SMACNA requirements for the specified pressure class. Ribbed and lightweight duct are not permitted.

F. Ductwork shall be suitable for velocities up to 5,000 fpm.

G. Divided flow fittings may be made as separate fittings or factory installed taps with sound, airtight, continuous welds at intersection of fitting body and tap.

H. Spot weld and bond all fitting seams in the pressure shell. Coat galvanizing damaged by welding with corrosion resistant paint to match galvanized duct color.

I. Ducts with minor axis less than 22" shall be spiral seam type. Larger ducts may be rolled, longitudinal welded seam type. SMACNA seams RL-2 and RL-3 are not permitted.

J. Reinforce flat oval ducts with external angles. Internal tie rods are permitted only as indicated for rectangular ductwork.

K. Transverse Joint Connections:

1. Crimped joints are not permitted.

2. Ducts and fittings 36" in diameter and smaller shall have slip joint connections. Size fitting ends to slip inside mating duct sections with minimum 2-inch insertion length and a stop bead. Use inside slip couplings for duct-to-duct joints, and outside slip couplings for fitting-to-fitting joints.

3. Ducts and fittings larger than 36" shall have flanged connections.

4. Secure all joints with at least 3 sheet metal screws before sealing.

5. Slide-on flanges as manufactured by Ductmate Industries, Accuflange, or Sheet Metal Connectors are acceptable. Self-sealing duct systems are also acceptable (Lindab, Ward “Keating Coupling”).

2.6 EXPOSED DUCTWORK (RECTANGULAR, ROUND, AND FLAT OVAL)

A. The following applies to all ductwork exposed in finished areas including the apparatus bay in addition to requirements noted above:

1. Provide extra shipping protection. Use Cardboard or other protective means to prevent dents and deformed ends.

2. Provide cardboard or other means of protection during field fabrication. Protect from scratches. Provide stiffeners to retain shape during fabrication.

3. Remove all identification stickers and thoroughly clean exterior of all ducts.

4. Locate fitting seams on least visible side of duct.

5. Provide exterior finish suitable for field painting without further oil removal.

6. Provide ramp-type internal joint couplings. Provide bead of sealant around the inside of the duct about 1/2" from the end of the duct. Slide-on flanges as manufactured by Ductmate Industries, Accuflange or Sheet Metal Connectors are acceptable. Self-sealing duct system is also acceptable (Lindab, Ward "Keating Koupling").

7. The system shall be free of visible dents and scratches when viewed from normal occupancy.

8. All insulation shall be internal, except at reheat coils.

B. Alternate manufacturers, including shop fabricated duct, must be reviewed before installation. The following information is required:

1. Metal gauge of duct and fittings.
2. Fitting type and construction.
3. Type and size of reinforcement.

2.7 FLEXIBLE DUCT

A. Flexible duct shall be listed and labeled as UL 181 Class 1 Air Duct Material, and shall comply with NFPA 90A and 90B, and meet GSA, FHA and other U.S. Government agency standards. Flexible duct shall bear the ADC Seal of Certification.

B. Flame Spread/Smoke Developed: Not over 25/50.

C. Flexible duct shall have corrosion-resistant wire helix, bonded to an inner liner that prevents air from contacting the insulation, covered with minimum 1-1/2", 3/4 lb/cf density fiberglass insulation blanket, sheathed in a vapor barrier of metalized polyester film laminated to glass mesh.

D. Inner liner shall be airtight and suitable for 6" WC static pressure through 10" diameter and shall be airtight and suitable for 4" WC static pressure 12" through 16" diameter. Outer jacket shall act as a vapor barrier only with permeance not over 0.1 perm per ASTM E96, Procedure A. "R" value shall not be less than 4.0 ft^2*ºF*hr/Btuh. Temperature range of at least 0-180ºF. Maximum velocity of 4,000 fpm.

E. Usage:

1. Take-offs from supply ducts to inlets of terminal air boxes. Do not exceed 36" in length.

2. Connections to air inlets and outlets. Do not exceed 3'-0" in length.

F. Stretch all flexible duct to prevent sags and reduce air friction. Shorten and reinstall all sagging or loose flexible duct. Avoid sharp elbows. Elbows shall maintain 1.5 diameter centerline turning radius.

G. Install per the SMACNA Flexible Duct Manual. Secure inner layer with draw band. Wrap with pressure sensitive tape for protection prior to installing draw band. Pressure sensitive tape alone is not acceptable.

2.8 GREASE EXHAUST DUCT

A. Exposed ductwork shall be 16 gauge minimum, Type 304L stainless steel. Concealed ductwork may be 16 gauge black steel.

B. All joints and fittings shall be continuously welded and liquid-tight.

C. Exposed ductwork shall have a #3 finish. Concealed ductwork may have a mill finish.

D. Do not penetrate fire rated partitions, unless protected as required by applicable codes.

E. Provide pre-fabricated access doors and labels required by NFPA 96 on sides of duct at least 1.5" from bottom. Provide access at each change in direction and at maximum 20-foot intervals in horizontal ducts. Provide access at every floor for vertical ducts.

F. Where grease ducts are 20" x 20" or larger, install access for personnel to enter duct. Duct supports must be sized to support the duct weight and an additional 800 lbs per NFPA 96.

G. Install ducts with proper clearance to combustible and limited-combustible materials.

H. Grease ducts installed with volume dampers shall conform to the damper specified in ductwork accessories.

I. Refer to Section 23 07 13 for duct insulation material and insulated access door when required to provide proper enclosure of ductwork.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide openings in ducts for thermometers and controllers.

B. Locate ducts with space around equipment for normal operation and maintenance.

C. Do not install ducts or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the electrical equipment. Unless intended to serve these rooms, do not install any ductwork or equipment in electrical rooms, transformer rooms, electrical closets, telephone rooms or elevator machine rooms

D. During construction provide temporary closures of metal or taped polyethylene on open ducts to prevent dust from entering ductwork. Supply ductwork shall be free of construction debris, and shall comply with level "B" of the SMACNA Duct Cleanliness for New Construction Guidelines.

E. Repair all duct insulation and liner tears.

F. Install manual volume dampers in branch supply ducts so all outlets can be adjusted. Do not install dampers at air terminal device or in outlets, unless specifically shown.

G. Insulate terminal air box reheat coils. Seal insulation tight to form a tight vapor barrier.

H. Install flexible duct in accordance with the ADC Flexible Duct Performance and Installation Standards.

I. Flexible duct shall NOT be joined to flat-oval connections. Provide sheet metal oval-to-round transitions where required, to include, but not limited to, all connections to air inlets, air outlets, and terminal air boxes.

J. Install all exterior ductwork per SMACNA Fig. 6-3. Where drawings do not indicate otherwise, ductwork seams and joints shall be sealed watertight and pitched to shed water.

K. Support all duct systems in accordance with the SMACNA HVAC Duct Construction Standards: Metal and Flexible and the SMACNA Seismic Restraint Manual: Guidelines for Mechanical Systems, where applicable. Refer to Section 23 05 50 for seismic requirements.

L. Adhesives, sealants, tapes, vapor retarders, films, and other supplementary materials added to ducts, plenums, housing panels, silencers, etc. shall have flame spread/smoke developed ratings of under 25/50 per ASTM E84, NFPA 255, or UL 723.

3.2 DUCTWORK APPLICATION SCHEDULE

USAGE	MATERIAL	PRESSURE CLASS	SEAL CLASS†	INSULATION (Refer to Section 23 07 13 for insulation types)
Supply Duct from Fan to Terminal Air Boxes – Single Wall	Galvanized Sheet Metal - Rectangular	+3"	A	1-1/2" thick Type A
Supply Duct from Fan to Terminal Air Boxes – Single Wall	Galvanized Sheet Metal - Round	+3"	A	1-1/2" thick Type A
Supply Duct from Fan to Terminal Air Boxes	Galvanized Sheet Metal w/Slide-On Flange System or Formed-on Flanges	+3"	A	1-1/2" thick Type A
Supply Duct from Terminal Air Boxes to Outlets	Galvanized Sheet Metal - Rectangular	+2″	A	1-1/2″ thick Type A.
Supply Duct from Terminal Air Boxes to Outlets	Galvanized Sheet Metal - Round	+2″	A	1-1/2″ thick Type A.
Return Duct	Galvanized Sheet Metal	-2"	A	None
Exhaust Duct from Fan to Terminal Air Boxes	Galvanized Sheet Metal	-3″	A	None
Exhaust Duct from Terminal Air Boxes to Outlets	Galvanized Sheet Metal - Rectangular	-2″	A	None
Exhaust Duct from Terminal Air Boxes to Outlets	Galvanized Sheet Metal - Round	-2″	A	None
Outside Air Intake from Louver to ERU/AHU	Galvanized Sheet Metal	-2"	A	2" thick Type B
Mixed/Make-up Air Duct	Galvanized Sheet Metal	-2"	A	2" thick Type B
	Galvanized Sheet Metal	+2"	A	2" thick Type B
Relief Air Louver to Relief Damper	Galvanized Sheet Metal	+2"	A	2" thick Type B
Transfer Ducts	Galvanized Sheet Metal	-1/2"	---	1" thick Type C
Ductwork Accessories (Fabric Flex Connectors, Equipment Flanges, etc.)	---	---	---	1-1/2″ thick Type A
All Terminal Air Box/ Reheat Coil Headers and Duct Mounted Coil Headers	--	--	---	1-1/2″ thick Type A
† Seal Class is per SMACNA HVAC Air Duct Leakage Test Manual				

3.3 DUCTWORK SEALING

A. General Requirements:

1. Openings, such as rotating shafts, shall be sealed with bushings or similar.

2. Pressure sensitive tape shall not be used as the primary sealant unless it has been certified to comply with UL-181A or UL-181B by an independent testing laboratory and the tape is used in accordance with that certification.

3. All connections shall be sealed including, but not limited to, taps, other branch connections, access doors, access panels, and duct connections to equipment. Sealing that would void product listings is not required. Spiral lock seams need not be sealed.

4. Mastic-based duct sealants shall be applied to joints and seams in minimum 3 inch wide by 20 mil thick bands using brush, putty knife, trowel, or spray, unless manufacturer's data sheet specifies other application methods or requirements.

B. For Seal Class A ducts, all transverse joints, longitudinal seams, and duct wall penetrations shall be sealed. Joints are inclusive of, but not limited to, girth joints, branch and sub-branch intersections, duct collar tap-ins, fitting subsections, louver and air terminal connections to ducts, access door and access panel frames and jambs, duct, plenum, and casing abutments to building structures.

3.4 TESTING

A. Duct - 2" WG or Less (positive or negative):

1. Systems shall not leak more than shown in Table 4-1 of SMACNA HVAC Air Duct Leakage Test Manual for Seal Class A.

2. Leak testing of these systems is not normally required for interior ductwork. However, leak tests will be required if, in the opinion of the Architect/Engineer, the leakage appears excessive. All exterior ductwork shall be tested. If duct has outside wrap, testing shall be done before it is applied.

3. Leak test shall be at the Contractor's expense and shall require capping and sealing all openings.

4. Seal ducts to bring the air leakage into compliance.

5. Contractor shall notify the Architect/Engineer five business days prior to pressurizing ductwork for testing.

B. Duct - 3" WG and Above (positive or negative):

1. Duct system shall be completely pressure tested. If duct has outside wrap, testing shall be done before it is applied.

2. Leak test shall be at the Contractor's expense and shall require capping and sealing all openings.

3. Seal ducts to bring the air leakage into compliance.

4. Contractor shall notify the Architect/Engineer five business days prior to pressurizing ductwork for testing.

C. Test procedure shall be as listed in the latest edition of the SMACNA HVAC Duct Leakage Manual, with the following additional requirements:

1. Test pressure shall be the specified duct pressure class. Testing at reduced pressures and converting the results mathematically is not acceptable. This is required to test the structural integrity of the duct system.

2. If any leak causes discernible noise at a distance of 3 feet, that leak shall be eliminated, regardless of whether that section of duct passed the leakage test.

3. All joints shall be felt by hand, and all discernible leaks shall be sealed.

4. Totaling leakage from several tested sections and comparing them to the allowable leakage for the entire system is not acceptable. Each section must pass the test individually.

5. Contractor shall notify the Architect/Engineer five business days prior to pressurizing ductwork for testing. Failure to notify the Architect/Engineer of pressure testing may require the contractor to repeat the duct pressure test after proper notification.

6. Upon completion of the pressure test, the contractor shall submit an air duct leakage test summary report as outlined in the SMACNA HVAC Duct Leakage Test Manual.

7. All access doors, taps to terminal air boxes, and other accessories and penetrations must be installed prior to testing. Including terminal air boxes in the test is not required.

8. The required leakage class for Seal Class A, both round and rectangular ducts, shall be 4.

9. Positive pressure leakage testing is acceptable for negative pressure ductwork.

D. Grease Exhaust Duct:

1. A light test shall be performed by passing a lamp having a power rating of not less than 100 watts through the entire section of ductwork to be tested. The lamp shall be open to emit light equally in all four directions.

2. Testing of the entire exhaust duct system including the hood-to-duct connection shall be performed. Ductwork shall be permitted to be tested in sections provided every joint is tested.

3. Leakage testing shall occur prior to use or concealment of the duct system. Ducts shall be considered concealed where installed in shafts or covered by insulation or wrap that prevents ductwork from being visibly inspected on all sides. The test shall be performed in the presence of the code official.

3.5 DUCTWORK PENETRATIONS

A. All duct penetrations of firewalls shall have fire or fire/smoke dampers where required by code.

B. Dampers shall be compatible with fire rating of wall assembly. Verify actual rating of any wall being penetrated with Architect/Engineer.

C. Seal all duct penetrations of walls that are not fire rated by caulking or packing with fiberglass. Install galvanized steel (unless otherwise indicated) trim strip to cover vacant space and raw construction edges of all rectangular openings in finished rooms.

END OF SECTION

SECTION 23 33 00
DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Manual Volume Dampers.
B. Fabric Connectors.
C. Duct Access Doors.
D. Duct Test Holes.

1.2 SUBMITTALS

A. Submit shop drawings under provisions of Section 23 05 00.

B. Submit manufacturer's installation instructions.

PART 2 - PRODUCTS

2.1 MANUAL VOLUME DAMPERS

A. Fabricate in accordance with SMACNA Duct Construction Standards, and as indicated.

B. Fabricate single blade dampers for duct sizes to 9-1/2 x 30 inches.

C. Fabricate multi-blade damper of opposed blade pattern with maximum blade sizes 12" x 72". Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.

D. Except in round ductwork 12 inches and smaller, provide end bearings. On multiple blade dampers, provide molded synthetic or oil-impregnated nylon or sintered bronze bearings.

E. Provide locking quadrant regulators on single and multi-blade dampers.

F. On insulated ducts, mount quadrant regulators on stand-off mounting brackets, bases, or adapters.

G. If blades are in open position and extend into the main duct, mount damper so blades are parallel to airflow.

2.2 FABRIC CONNECTORS

A. Fabric connectors shall be installed between all fans or fan units and metal ducts or casings to prevent transfer of fan or motor vibration.

B. The fabric connectors shall be completely flexible material which shall be in folds and not drawn tight.

C. Fabric connectors shall be of glass fabric double coated with neoprene, with UL approval. Weight = 30 oz. per square yard minimum. Fabric shall not be affected by mildew and shall be absolutely waterproof, airtight and resistant to acids, alkalies, grease and gasoline, and shall be noncombustible.

D. Fabric connections shall not exceed 6" in length on ductwork that has a positive pressure. On ductwork that has a negative pressure, the length shall not exceed 2" in length.

E. All corners shall be folded, sealed with mastic and stapled on 1" centers.

F. Fabric connectors shall not be painted.

G. Unless otherwise shown on the drawings, the fabric connection at the inlet to centrifugal fans shall be at least one duct diameter from the fan to prevent inlet turbulence.

H. Acceptable Materials: Durodyne MFN-4-100, Vent Fabrics, Inc. "Ventglas", or Proflex PFC3NGA.

I. Fabric connectors exposed to sunlight and weather shall be as described above, except the coating shall be hypalon in lieu of neoprene.

J. Acceptable Materials: Durodyne "Duralon MFD-4-100", Vent Fabrics, Inc. "Ventlon", or Proflex PFC3HGA.

2.3 DUCT ACCESS DOORS

A. Fabricate per Fig. 7-2 and 7-3 of the SMACNA HVAC Duct Construction Standards and as indicated.

B. Review locations prior to fabrication. Install access doors at fire dampers, smoke dampers, motorized dampers, fan bearings, filters, automatic controls, humidifiers, louvers, duct coils and other equipment requiring service inside the duct.

C. Construction shall be suitable for the pressure class of the duct. Fabricate rigid, airtight, and close-fitting doors of materials identical to adjacent ductwork with sealing gaskets butt or piano hinges, and quick fastening locking devices. For insulated ductwork, install minimum one inch thick insulation with sheet metal cover.

D. Access doors with sheet metal screw fasteners are not acceptable.

E. Minimum size for access doors shall be 24" x16" or full duct size, whichever is less.

F. Provide quantity of access doors such that two hands can fit inside ductwork to manually reset fire dampers. This will typically require one access door on the bottom and one access door on an accessible side of the duct for sizes 12x12 and smaller.

2.4 GREASE DUCT ACCESS DOORS

A. Provide pre-fabricated and pre-insulated duct access doors by the same manufacturer as the fire resistive duct wrap.

2.5 DUCT TEST HOLES

A. Cut or drill temporary test holes in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install accessories in accordance with manufacturer's instructions.

2. Where duct access doors are located above inaccessible ceilings, provide ceiling access doors. Coordinate location with the Architect/Engineer.

3. Coordinate and install access doors provided by others.

4. Provide access doors for all equipment requiring maintenance or adjustment above an inaccessible ceiling. Minimum size shall be 24” x 24”.

5. Grease duct access doors shall be installed per approvals from manufacturer's ICC-ES Evaluation Report.

6. Provide duct test holes where indicated and as required for testing and balancing purposes.

B. Manual Volume Damper:

1. Provide manual volume dampers at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts where indicated on drawings and as required for air balancing. Use splitter dampers only where indicated.

2. Provide ceiling access doors for manual volume dampers. When manual volume dampers are located above an inaccessible ceiling and an access door cannot be installed, provide a remote controlled volume control device for operation of the damper. Coordinate location with the Architect/Engineer.

3. Grease duct volume dampers shall be continuously welded to duct and/or hoods so that system is liquidtight.

END OF SECTION

SECTION 23 34 23
POWER VENTILATORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Cabinet Fans
B. Roof Exhaust Fans.
C. Rooftop Fan Curbs.
D. Wall Exhausters.
E. Propeller Fans.
F. Ceiling Fans.

1.2 QUALITY ASSURANCE

A. Performance Ratings: Conform to AMCA 210 and bear AMCA Certified Rating Seal.

B. Sound Ratings: AMCA 301, tested to AMCA 300.

C. Fabrication: Conform to AMCA 99.

1.3 SUBMITTALS

A. Submit shop drawings per Section 23 05 00. Include product data on wall and roof exhausters, and ceiling and cabinet fans.

B. Provide multi-rpm fan curves with specified operating point clearly plotted.

C. Submit manufacturer's installation instructions.

PART 2 - PRODUCTS

2.1 CABINET FANS

A. Housing:

1. Heavy gauge steel reinforced and braced with steel angle framework.
2. Cleaned, phosphatized and painted with enamel or constructed entirely of galvanized steel.
3. Removable access panels for fan removal.
4. Insulate fan section interior with 1" thick, 3/4 lb. density fiberglass.
5. Insulated, corrosion-resistant drain pan under fan sections.
6. Minimum 12" x 18" hinged access doors on both sides of fan housing.

B. Fan:

1. Double width, double inlet, forward curved centrifugal, statically and dynamically balanced.
2. Grease lubricated ball bearings, rated for 200,000 hours L-50 life at design operating conditions.
3. Extend lubrication lines for all bearings to an easily accessible location.

C. Motors and Drives:

1. Motor shall have slide rails, adjusting screws, anchor bolts and bedplates.

2. Open drip-proof motors with grease lubricated bearings, minimum 1/3 HP.

3. Furnish factory mounted and wired disconnect switch, non-fusible type with thermal overload protection.

D. Acceptable Manufacturer: Greenheck, Cook, Aerovent.

2.2 ROOFTOP EXHAUST FAN - VERTICAL DISCHARGE - DIRECT DRIVEN

A. Fan Wheel: Centrifugal type, aluminum hub and wheel with backwards inclined blades, statically and dynamically balanced.

B. Housing: Removable, spun aluminum dome or rectangular top, with square, one piece, aluminum base and curb cap with Venturi inlet cone.

C. Fan Shaft: Turned, ground and polished steel; keyed to wheel hub.

D. Motor mounted outside of air stream and ventilated with outside air. Motor not less than 1/3 HP.

E. Furnish permanently lubricated sealed ball type motor and drive shaft bearings sized for 200,000 hours life at specified operating conditions. Drives sized for 150% of rated motor horsepower. Drive assembly and wheel supported by vibration isolators. Motor shall be ECM type per 23 05 13.

F. Include ventilated curb cap and hinged base with restraining means.

G. All fans serving range hoods shall have extended shrouds to discharge at least 40" above roof and built-in grease trough with drain.

H. Mill aluminum finish.

I. Acceptable Manufacturers: ACME, Greenheck, Penn, Twin City.

2.3 ROOFTOP FAN CURBS

A. Furnish and install prefabricated roof curbs for all rooftop fans.

B. Size curb to match the curb cap of fan.

C. Top of all curbs shall be at least 12" above the top of the roof. Increase curb height to allow for roof insulation.

D. Unitized construction, continuous arc welded corner seams. Insulated with 1-1/2" thick, 3 lb. density rigid fiberglass board. Damper support angle. Pressure treated wood nailer.

E. If called for in the drawings, curbs shall be of the sound attenuation type. Sound attenuation curbs shall reduce the fan sone rating by at least 40% and not decrease fan cfm more than 8% (which is accounted for in the scheduled fan cfm). Baffles shall be removable for access to the dampers.

F. 14-gauge aluminum construction.

G. Curb without cant.

H. Acceptable Manufacturers: Same manufacturer as the fan, Pate, RPS or Thy.

2.4 PROPELLER FANS

A. Direct-driven as scheduled propeller fans consisting of fan blades, hub, housing, orifice ring, motor, drive assembly, and accessories. Motor shall be ECM type per 23 05 13.

B. Galvanized steel sheet, all welded, and integral Venturi orifice ring with baked-enamel finish coat applied after assembly.

C. Formed-steel blades riveted to heavy-gage steel spider bolted to cast-iron hub.

D. Extruded-aluminum blades fastened to cast-aluminum hub; factory set pitch angle of blades.

E. Provide galvanized steel motor-side back guard complying with OSHA specifications, removable for maintenance.

F. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.

G. Shaft Bearings: Permanently lubricated, L_{10} of 100,000 hours, permanently sealed, self-aligning ball bearings.

H. Provide with the following accessories:

1. Variable-Speed Controller: Integral Variable frequency drive control to reduce speed from 100 percent to less than 50 percent.

2. Disconnect Switch: Non-fusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

I. Acceptable Manufacturers: Aerovent, Cook, Greenheck, ACME, Penn, Carnes.

2.5 CEILING FANS

A. The fan shall be designed to move an effective amount of air for cooling and destratification in large industrial applications over an extended life. The fan and components shall be designed specifically for high volume, low speed fans to ensure lower noise operation. The sound levels from the fan operating at maximum speed shall not exceed 55 dBA (measured 20' or 6.1 m below the blades and 20' or 6.1 m horizontally from the center of the fan).

B. The fan shall be direct drive.

C. The fan shall be equipped with a mounting post that provides a structural connection between the fan assembly and upper mounting system. As an option, mounting post may be colored as specified by the architect or owner.

D. The fan mounting system shall be designed for quick and secure installation from a structural support beam. All components in the mounting system shall be of welded construction using low carbon steel no less than 3/16" (0.5 cm) thick and be powder coated for appearance and resistance to corrosion. All mounting bolts shall be SAE Grade 8 or equivalent. As an option, mounting components may be colored as specified by the architect or owner.

E. The fan controller shall be constructed using a Variable Speed Drive (VSD) that is factory programmed to minimize the starting and braking torques, for smooth and efficient operation. Provide wall wiring between VSD and fan as required for installation.

F. The fan shall be equipped with remote wall control. The wall control shall be equipped with touchpad controls and an LED display for controlling the fan's direction, operation and speed. Communication with the fan drive and controller shall be by a standard commercially available CAT-5 (or higher) Ethernet cable that is field installed and provided by the mechanical contractor. Wall controller shall be able to control 4 fans simultaneously.

G. Fan shall include an input from fire alarm dry contacts to shut down fan during a fire alarm event. Input shall be located at the fan.

H. Fan shall also include relay contacts to shut down the fan from the DDC control system. Fan shall return to last speed operation after shutdown from DDC system. Input shall be located at the fan.

I. The manufacturer shall replace any products or components defective in material or workmanship, free of charge to the customer (including transportation charges within the USA), pursuant to the complete terms and conditions of the manufacturer's warranty in accordance to the following schedule:

1. Blades Lifetime (Parts)

2. Hub Lifetime (Parts)

3. Motor 3 years (Parts)

J. Acceptable Manufacturer: MacroAir or BigAss.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Secure roof exhausters with cadmium plated lag screws to roof curb.

C. If manufacturer has no recommendations, secure roof exhaust fans to curbs with 1/4" lag bolts on 8" maximum centers.

D. MC shall install and wire factory provided damper to open when the fan runs if the manufacturer does not provide an option to pre-wire the damper.

END OF SECTION

SECTION 23 36 00
AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Single Duct Variable Air Volume Terminal Box.

1.2 REFERENCES

A. NFPA 70 - National Electric Code.
B. NFPA 90A - Installation of Air-Conditioning and Ventilation Systems.
C. UL 181 - Factory-Made Air Ducts and Connectors.

1.3 SUBMITTALS

A. Submit shop drawings under provisions of Section 23 05 00.

B. Submit shop drawings indicating configuration, general assembly, and materials used in fabrication.

C. Submit product data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings which indicate airflow, static pressure, and NC designation.

D. Include schedules listing discharge and radiated sound power level for each of second through sixth octave bands at inlet static pressures of one to 4 inch WG.

E. Submit manufacturer's installation instructions.

1.4 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data.

B. Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists.

C. Include directions for resetting constant volume regulators.

PART 2 - PRODUCTS

2.1 ACOUSTICAL CONSIDERATIONS (THIS APPLIES TO ALL UNITS)

A. All units shall have noise data certified in accordance with AHRI Standard 885-98 with 5/8” 20-lb. density mineral fiber ceiling tile and shall not produce space noise values over NC-35 due to radiated and airborne noise combined.

2.2 SINGLE DUCT VARIABLE AIR VOLUME TERMINAL BOX

A. 18 gauge aluminum housing with internal components of aluminum and stainless steel.

B. Teflon bearings at moving parts and Neoprene seals.

C. Valve configuration for smooth variations in airflow.

D. Pressure independent operation without means of external monitoring devices. Box shall maintain constant volume at all flow rates regardless of changes in upstream or downstream static pressure.

E. Box shall be fully wrapped with elastomeric insulation.

F. Box shall be capable of controlling within 5% accuracy.

G. Unit shall have Belimo actuator.

H. Unit shall fail in last position.

I. Refer to control diagrams and notes on control drawings for complete sequence of control.

J. Acceptable Manufacturers: Accutrol.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Maintain minimum working clear space for all electrical connections in accordance with NFPA 70, National Electrical Code.

C. Provide ceiling access doors or locate units above easily removable ceiling components.

D. Support units individually from structure. Do not support from adjacent ductwork.

E. Where boxes are located adjacent to a wall or joist, the damper motors and control valves shall be located on the side of the box away from the wall or joist to permit easy access.

3.2 ADJUSTING

A. All boxes shall be set to the cfm shown on the drawings. TCC shall be responsible to field recalibrate all boxes that are not set correctly.

END OF SECTION

SECTION 23 37 00
AIR INLETS AND OUTLETS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Commercial Exhaust Range Type 1 Hood
B. Variable Volume Type 1 Exhaust Hood Controller
C. Grilles And Registers.
D. Architectural Square Panel Diffusers.
E. Louvers.
F. Roof Curbs.

1.2 QUALITY ASSURANCE

A. Test and rate performance of air inlets and outlets per ASHRAE 70.

B. Test and rate performance of louvers per AMCA 500L-99.

C. All air handling and distribution equipment mounted outdoors shall be designed to prevent rain intrusion into the airstream when tested at design airflow and with no airflow, using the rain test apparatus described in Section 58 of UL 1995.

1.3 SUBMITTALS

A. Submit product data under provisions of Section 23 05 00.

B. Submit schedule of inlets and outlets indicating type, size, location, application, and noise level.

C. Review requirements of inlets and outlets as to size, finish, and type of mounting prior to submitting product data and schedules of inlets and outlets.

D. Submit manufacturer's installation instructions.

1.4 REGULATORY REQUIREMENTS

A. Conform to ANSI/NFPA 90A.

B. Conform to ASHRAE 90.1.

PART 2 - PRODUCTS

2.1 COMMERCIAL EXHAUST RANGE TYPE 1 HOOD

A. Hood shall be 18 gauge Type 304 stainless steel construction with #3 polished finish. All exterior seams shall be continuously welded, ground, and polished to match hood finish.

B. System should include stainless steel backsplash, sidesplashes, and end panels along with insulation on rear of unit.

C. Hood shall be furnished with UL classified baffle type stainless steel grease filters.

D. Provide UL listed 100 watt incandescent or LED equiavlent vapor-proof lights, pre-wired to junction box mounted on top of hood. Fixture shall have plastic coated glass.

E. Unit shall have NSF label and UL label in accordance with NFPA-96 for Type 1 hood applications.

F. Provide full NFPA wet chemical fire suppression system including storage tank control panel, piping, detectors, nozzles, manual pull station and mechanical gas shutoff valve. Cabinet shall be integrated into the top of the exhaust hood with top access from the front of the hood. Size system to meet the hood dimensions. System controls shall be integrated with controls for fans and lights. Acceptable Manufacturer: Ansul R-102 System.

G. Provide variable exhaust system controller as specified below.

H. Hood manufacturer shall work with mechanical contractor shall submit plans to Department of Safety & Professional Services - State of Wisconsin for Commercial Kitchen Hood review. Hood manufacturer shall provide Professional Engineer stamp with submission.

I. Acceptable Manufacturers: Captive Aire, Halton, Avtec, Gaylord, Incorporated, Econovent.

2.2 VARIABLE VOLUME TYPE 1 EXHAUST HOOD CONTROLLER

A. Operator shall automatically control speed of exhaust fan, and make-up air if applicable, to ensure optimal hood performance.

B. Control system shall include I/O processor, keypad, temperature sensors, optic sensors, cables, and analog output for control of ECM exhaust fan.

C. Keypad shall control exhaust fans and lights associated with hood.

D. Install I/O processor, keypad and electronic motor starters in a cabinet.

E. Install one temperature sensor in each exhaust collar.

F. Install optic sensors to monitor smoke inside the ends of each Type 1 hood with air purge units mounted on top.

G. Factory install controller in hood.

H. Controller shall be warranted for three years from time of purchase.

I. Controller shall be UL and CSA listed.

J. Acceptable Manufacturers: Melink Intelli-Hood Control System or CaptiveAire

2.3 GRILLES AND REGISTERS

A. Reference to a grille means an air supply, exhaust or transfer device without a damper.

B. Reference to a register means an air supply, exhaust or transfer device with a damper.

C. The type of unit, margin, material, finish, etc., shall be as shown on the drawing schedule and suitable for the intended use.

D. All margins shall be compatible with ceiling types specified (including 'Thin-Line' T-bar lay-in grid system). Any discrepancies in contract documents shall be brought to the attention of the Architect/Engineer, in writing, prior to Bid Date. Submission of Bid indicates ceiling and air inlet and outlet types have been coordinated.

E. The capacity and size of the unit shall be as shown on the drawings.

F. All units shall handle the indicated cfm as shown on the drawings while not exceeding an NC level of 25, referenced to 10^{-12} watts with a 10 dB room effect.

G. Refer to the drawings for construction material, color and finish, margin style, deflection, and sizes of grilles and registers.

H. Provide with 3/4" blade spacing. Blades shall have steel friction pivots to allow for blade adjustment, plastic pivots are not acceptable.

I. Corners of steel grilles and registers shall be welded and ground smooth before painting. Aluminum grilles and registers shall have staked corners.

J. Where specified to serve registers, provide opposed blade volume dampers operable from the face of the register.

K. Screw holes for surface fasteners shall be countersunk for a neat appearance. Provide concealed fasteners for installation in lay-in ceilings and as specified on the drawings.

L. Acceptable Manufacturers: Tuttle & Bailey, Titus, Price, Nailor, Carnes, Metalaire, Krueger.

2.4 ARCHITECTURAL SQUARE PANEL DIFFUSERS

A. Reference to a diffuser means an air supply device, ceiling mounted, that shall diffuse air uniformly throughout the conditioned space.

B. The type of unit, margin, material, finish, etc., shall be as shown on the drawing schedule. Flat-oval inlets are not acceptable for connection to flexible ducts.

C. All margins shall be compatible with ceiling types specified (including 'Thin-Line' T-bar lay-in grid system). Any discrepancies in contract documents should be brought to the attention of the Architect/Engineer, in writing, prior to Bid Date. Submission of Bid indicates ceiling and air inlet and outlet types have been coordinated.

D. The capacity and size of the unit shall be as shown on the drawings.

E. All units shall handle the indicated cfm as shown on the drawings while not exceeding an NC level of 25, referenced to 10^{-12} watts with a 10 dB room effect.

F. Diffusers shall be architectural solid square panel and flush with ceiling.

G. The exposed surface shall be smooth, flat and free of visible fasteners. The face panel shall be 22 gauge steel with a rolled edge or shall be 18 gauge with a smooth ground, uniform edge.

H. The back pan shall be one piece 22 gauge stamped and shall include an integral inlet. (Welded inlets and corner joints are not acceptable).

I. Diffusers with a 24x24 back pan shall have a minimum 18x18 face panel size. Diffusers with a 12x12 back pan shall have a minimum 9x9 face panel size.

J. The face panel shall be mechanically fastened to the back panel with steel components. (Plastic fasteners are not acceptable.)

K. Acceptable Manufacturers: Tuttle & Bailey, Titus, Price, Nailor, Carnes, Metalaire, Krueger.

2.5 LOUVERS - FIXED - ALUMINUM

A. Louvers shall be minimum 4" deep and constructed of extruded aluminum. Blade, jamb and sill thickness shall be minimum 0.081". Blades shall be spaced at a maximum of 5.1" apart.

B. Louvers shall be of the drainable blade design with water collected on the leading edge of the blade and diverted to the jamb.

C. Louvers shall be furnished with aluminum bird screen mounted on the outside surface.

D. Size, cfm, finish and pressure drop for louvers shall be as scheduled on the drawings.

E. AMCA Certified performance for 48" x 48" samples with intake airflow of 8,000 cfm shall not exhibit more than 0.19" pressure drop. Maximum water penetration shall be 0.01 ounces per square foot at the scheduled intake velocity based on 15 minute test duration when subjected to a water flow rate of 0.25 gal/min as described under the Water Penetration Test in AMCA 500-L-07.

F. Contractor shall provide the General Contractor with the correct sizes and locations of all louvers required in masonry walls.

G. Louvers shall be sealed around perimeter to avoid moisture penetration between the louver frame and wall.

H. Louvers shall be suitable for duct connection.

I. Acceptable Manufacturers: Air Flow - “EA-403”, Arrow - “EA-415-D", American Warming & Ventilating - “LE-21", Construction Specialties - “A4097", Dowco - “DBE-4", Louvers & Dampers, Inc. - “IL-23", Ruskin - “ELF375DX”, Vent Products - “2760", Greenheck - “ESD-403", Pottorff - “EFD”.

2.6 ROOF CURBS

A. Furnish and install, where shown on the drawings, prefabricated roof curbs for all rooftop hood openings.

B. Curbs shall be sized to match curb cap of the hood. The top of all curbs shall be 12" above the top of the roof.

C. Curbs shall be unitized construction, 14 gauge aluminum, with continuous arc welded corner seams, insulated with 1-1/2" thick, 3 lb. density rigid fiberglass board and damper support angle.

D. Curb without cant – suitable for use with membrane type roof.

E. Acceptable Manufacturers: Same manufacturer as the equipment it serves or Pate, RPS, or Thy.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install items in accordance with manufacturers' instructions.

2. Install seismic restraints according to SMACNA’s “Kitchen Equipment Fabrication Guidelines, Appendix 1, “Guidelines for Seismic Restraints for Kitchen Equipment".

3. Check location of inlets and outlets and make necessary adjustments in position to conform to architectural features, symmetry, and lighting arrangement.

4. Install diffusers to ductwork with air tight connections.

5. Flexible ducts shall NOT be joined to flat-oval connections. Provide sheet metal oval-to-round transitions where required.

B. Volume Damper:

1. Provide manual volume dampers on duct take-off to diffusers when there are multiple connections to a common duct. Locate volume dampers as far as possible from the air inlet or outlet.

C. Roof Hood and Louvered Penthouse:

1. If manufacturer has no recommendations, secure roof hoods and louvered penthouses to curbs with 1/4" lag bolts on 8" maximum centers.

2. Provide 20 gauge sheet metal duct blank-off behind louvers at unused portions of louver openings in exterior walls. Back with 2" rigid 3# density fiberglass board insulation with foil scrim facing the room. Seal watertight.

END OF SECTION

SECTION 23 40 00
AIR CLEANING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Filters and Filter Media.
B. Activated Carbon Filters.
C. Filter Frames.
D. Filter Gauges.

1.2 QUALITY ASSURANCE

A. Filter media shall be tested under ANSI/UL 900 and labeled.

B. Provide all filters and filter banks by one manufacturer.

1.3 SUBMITTALS

A. Submit shop drawings per Section 23 05 00. Include data on media, performance, assembly and frames.

1.4 EXTRA STOCK

A. Provide clean filters in all units at time of installation.

B. Provide clean filters in all units at project final completion after all interior finishes are complete and as needed for the TAB Contractor to perform their work..

C. Provide one additional set of replacement filters for all units. Deliver to Owner at job site.

PART 2 - PRODUCTS

2.1 MEDIUM EFFICIENCY - DISPOSABLE

A. Non-woven cotton fabric, pleated media, disposable type with welded wire grid support bonded to the filter media.

B. Heavy duty, paper board frame with diagonal support members bonded to inlet and exit sides of each pleat. Bond frame to media periphery to eliminate air bypass.

C. 4" thick media. Maximum initial resistance of 0.26" WG at 500 fpm face velocity.

D. 25-30% efficiency and 90-92% arrestance per ASHRAE 52.1 or MERV 8 per ASHRAE 52.2.

2.2 80% EFFICIENCY - DISPOSABLE

A. Non-woven cotton fabric, pleated media, disposable type with welded wire grid support bonded to the filter media.

B. Heavy duty, paper board frame with diagonal support members bonded to inlet and exit sides of each pleat. Bond frame to media periphery to eliminate air bypass.

C. 4" thick media. Maximum initial resistance of 0.20" WG at 500 fpm face velocity.

D. 80% efficiency and 98% arrestance per ASHRAE 52.1 or MERV 13 per ASHRAE 52.2.

2.3 FILTER GAUGES

A. Differential Pressure Gauge: Diaphragm actuated, nominal 3" round dial, glass filled nylon housing, polycarbonate lens, zero adjustment, 0-2" W.G. range, 5% of full scale accuracy.

B. Accessories: Static pressure tips with integral compression fittings and 1/8" NPT plastic tubing.

C. Acceptable Manufacturers: Dwyer "Minihelic II" 2-5000, Marshalltown Instrument “Series 85C”.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all products per manufacturers' instructions.

B. Seal filter media to prevent passage of unfiltered air around filters with felt, rubber, or neoprene gaskets.

C. Do not operate fan systems without filters.

D. Install static pressure tips upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum, in accessible position. Adjust and calibrate. Every filter bank, including packaged units, shall have a filter gauge.

E. Install four (4) high efficiency filter test holes. Two upstream and two downstream, at all high efficiency filter banks in air handling units and ductwork (85% efficiency and higher). Coordinate location of test holes with Owner.

END OF SECTION

SECTION 23 52 16
CONDENSING BOILERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Boilers.
B. Controls and Boiler Trim.
C. Hot Water Connections.
D. Fuel Burning System and Connection.
E. Vent Connection.
F. Boiler Vent Flue.

1.2 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing the products specified in this Section with at least three years documented experience.

B. Provide factory authorized start-up service by manufacturer's agent.

C. Conform to ANSI/ASME SEC 4 and ANSI/AGA Z21.13 for construction of boilers.

D. Boiler Units: AGA certified, UL listed and ASME certified.

E. Installation shall meet the requirements of ASME CSD-1, including remote emergency shutdown switches for boilers, applicable gas train, individual venting of gas regulators, and repackable shutoff valves at all boilers.

F. Conform to ASHRAE 90.1.

1.3 SUBMITTALS

A. Submit product data under provisions of Section 23 05 00.

B. Submit product data indicating general assembly, components, controls, safety controls, and wiring diagrams, and service connections.

C. Submit manufacturer's installation instructions.

D. Submit reports indicating condition and operation at start-up.

E. Submit reports indicating specified performance and efficiency is met or exceeded.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Protect boilers from damage by leaving factory inspection openings and shipping packaging in place until final installation.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data. Include manufacturer's descriptive literature, operating instructions, cleaning procedures, replacement parts list, and maintenance and repair data.

PART 2 - PRODUCTS

2.1 BOILERS

A. Provide factory assembled, factory fire-tested, self-contained unit ready for automatic operation except for connection of water, fuel, electrical, and vent services.

B. Unit: Hot water, condensing type boiler with integral forced draft burner, burner controls, boiler trim, insulation and jacket.

C. ASME allowable working pressure of 125 psig water.

D. Provide two lifting eyes on top of boiler.

E. Unit casing shall be a minimum of 16 gauge steel. Factory paint boiler, base, and other components with hard finish enamel.

F. Porcelain enameled or stainless steel exhaust manifold with gravity drain and reservoir for condensate elimination.

G. Boiler shall be intended for variable flow system.

H. Acceptable Manufacturer: Lochinvar (FTXL) or pre-approved equal.

2.2 HEAT EXCHANGER

A. Condensing, fire tube design surrounded by water that is suitable for return water temperatures as low as 80ºF. Heat exchanger shall be constructed of fully welded 316L stainless steel.

B. Ten-year non-prorated warranty against leakage due to thermal shock or corrosion.

2.3 BOILER FLUE

A. The boiler manufacturer shall furnish all vent flue and intake piping, fittings, dampers, and accessories as required to properly vent the equipment. Vent piping shall be UL listed for use IV appliances with operating temperatures of up to 480°F and shall be stainless steel materials.

2.4 HOT WATER BOILER TRIM

A. Provide ASME safety relief valve set at 50 psi maximum.

B. Provide low water cut-off with manual reset to automatically prevent burner operation whenever boiler water falls below safe level.

C. Provide operating temperature controller to control burner operation to maintain boiler water temperature, as determined by a remote 4-20 mA signal from building DDC system or boiler controller.

D. Limit temperature controller to control burner to prevent boiler water temperature from exceeding safe system water temperature.

E. Provide all trim required to meet ASME CSD-1. This includes, but is not limited to, gas train and all terminals and necessary relays for connection to remote shutdown switch(es) to disconnect all power to the burner controls.

2.5 FUEL BURNING SYSTEM

A. General: Forced draft automatic burner integral with boiler designed to burn natural gas at 8.5" to 14” W.C. inlet pressure. Maintain fuel-air ratios automatically.

B. Gas Burner: Forced draft, power burner with interrupted spark ignition and flame sensor.

C. Include on unit complete gas train including gas safety shutoff valve conforming to CSD-1 requirements. Vent all gas valves to outdoors separately.

D. Burner to be modulating with a minimum turndown ratio of 10:1.

2.6 CONTROL PANEL

A. The boiler system control panel shall include contacts for a trouble alarm to the DDC system. System shall include analog input from DDC system for boiler temperature setpoint control and digital input for boiler enable/disable.

B. The boiler system control panel shall include gateway device for BACnet Communications. Coordinate final connections with temperature control contractor.

C. The boiler control system shall modulate burner as required to maintain heating water temperature setpoint.

D. The boiler manufacturer shall supply boiler isolation valve for each boiler. Boiler control panel shall open isolation valve when boiler is operating. At no time shall all isolation valves on the boilers be closed.

E. Program relay to control ignition, starting and stopping of burner and provide both pre-combustion purge and post combustion purge. Burner to shut down in event of ignition, or main flame failure. Interlock to shut down burner upon combustion air pressure drop.

F. Manual-automatic selector switch to permit automatic firing in accordance with load demand, or manual control of firing rate at fixed temperature.

G. Panel to include indicating lights to show fault conditions of low water level, flame failure, fuel pressure, exhaust temperature, water temperature, or combustion air pressure. Mount indicating lights and switches in hinged drop-panel for access to wiring.

H. The boiler system control panel shall include contacts for a manual CSD-1 emergency shutdown switch. The switch shall be furnished, installed, and wired by the Electrical Contractor. Switch shall be located at each exit just outside the boiler room door or as shown on plans. If boiler room door is on exterior of building, the switch shall be located just inside the door or as shown on plans. Verify final location with Architect/Engineer. The switch shall disable all boilers and shall be wired to the boiler burner safety control circuit to interrupt burner operation. If electrical plans and specifications do not show switch and wiring, the Mechanical Contractor shall furnish, install, and wire.

I. Mechanical Contractor shall provide shutdown switch and associated wiring. The boiler shutdown switch shall be an emergency stop, mushroom head with N.C. contact, turn to release switch with engraved nameplate to read “BOILER EMERGENCY SHUTOFF”. Square D XAL K174 or as approved by Architect/Engineer.

2.7 PERFORMANCE

A. Minimum efficiency, verified by factory tests, shall be 91% at 100% output with 110°F return water and 96% at 25% output with 90°F return water.

B. Rated for return temperatures as low as 40°F and supply temperatures as high as 190°F.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Requirements:

1. Install in accordance with manufacturer's instructions.
2. Provide for connection to electrical service.
3. Provide connection of gas service in accordance with ANSI/AGA Z223.1.
4. Pipe safety relief valve and condensate trap to nearest floor drain. Route condensate pipe to acid resistant floor drain.
5. Install circulation pump as recommended by the manufacturer.

B. Combustion Inlet and Venting:

1. Provide complete sealed combustion inlet and venting system.
2. Slope all horizontal runs of exhaust vent towards the boilers at a slope of 1" per 4'.

C. Service Clearance:

1. Install the boilers with a minimum of three feet clear space behind them for installation of piping and services. Verify exact maintenance clearances required by the manufacturer prior to installation.

3.2 MANUFACTURER'S FIELD SERVICES

A. Prepare and start systems under factory authorized supervision.

B. Provide field representative for starting unit and training operator.

C. Provide combustion test and submit report. Test shall include boiler firing rate, overfire draft, gas flow rate, heat input, burner manifold gas pressure, percent carbon monoxide (CO), percent oxygen (O_2), percent excess air, flue gas temperature at outlet, ambient temperature, net stack temperature, percent combustion efficiency, and heat output.

END OF SECTION

SECTION 23 57 33
GEOTHERMAL HEAT EXCHANGERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Vertical Bore Type Ground Loop Geothermal Heat Exchanger.

1.2 QUALITY ASSURANCE

A. The Contractor must have on this project a certified IGSHPA installer. The Contractor performing this work must have a minimum of three years experience in performing underground closed circuit, earth coupled, vertical heat exchanger, including systems of 100 tons or larger.

B. Geothermal Heat Exchanger Fabricators must be heat fusion certified by an authorized high density polyethylene (HDPE) pipe manufacturer's representative of the brand of pipe used. Certification must include successful completion of a written heat fusion exam, as well as demonstrating proper heat fusion techniques under the direct supervision of the authorized HDPE pipe manufacturer's representative.

C. Certified technicians must attend a retraining school annually. A single failure of a fusion joint will void the certification, and the technician must be retested to demonstrate satisfactory performance.

D. Local, State, and Federal laws and ordinances, as they pertain to buried pipe systems, shall be strictly followed or a variance obtained. Installation shall follow the recommendations of the National Ground Water Association.

E. Procure and pay for all applicable permits and licenses.

F. Verify that survey benchmark and intended elevation of grade at well field prior to beginning work.

G. Grouting compound shall be certified and listed by NSF (National Sanitation Foundation International) to ANSI/NSF Standard 60, "*Drinking Water Treatment Chemicals - Health Effects*".

H. Drilling contractor shall be a licensed water well driller in the State of Wisconsin.

1.3 REFERENCES

A. ASTM D2610 – Solid Wall HDPE Conduit Based On Controlled Outside Diameter.

B. ASTM D2683 – Socket Fusion Fittings.

C. ASTM D3261 – Butt/Saddle Fusion Fittings.

D. ASTM D3350-93 – Polyethylene Plastic Pipe and Fittings.

E. International Ground Source Heat Pump Association (IGSHPA).

1.4 SHOP DRAWINGS

A. Submit shop drawings per Section 23 05 00.

B. Before geothermal heat exchanger construction begins, the Contractor must submit shop drawings to the Design Architect/Engineer. The shop drawings shall include all applicable manufacturer's material specifications, warranties, installer qualifications, material safety data sheets for all materials used in the geothermal installation, all polyethylene piping and fitting materials, U-bend assemblies, and testing and flushing procedure.

C. Submit detailed 1"=20' scale CAD drawing showing bore field layout, including site utilities and obstructions. Drawing shall include all horizontal pipe routing.

D. Submit all underground piping pressure test results.

1.5 DESCRIPTION OF WORK

A. This design has been prepared in accordance with the materials standards and accepted installation practices of the International Ground Source Heat Pump Association (IGSHPA). The Geothermal Contractor shall comply with these standards and practices along with all state and local regulations pertaining to the installation.

B. The Geothermal Contractor is responsible for all aspects involved with the complete geothermal loop field installation. All materials, drilling, excavation, hauling of backfill, pumping, soil compaction, utilities (including but not limited to water, electricity and fuel), and labor required shall be included in the bid price.

C. The Geothermal Contractor shall verify exact locations of utilities in the loop field. Some areas may require hand digging to locate utilities. The Geothermal Contractor must include in the bid price the repair of any sewer, domestic water, electrical, communication or any service line that may be damaged during the construction of this project. Any offsets required to route over or under existing lines shall also be included in the bid price of the project.

D. Refer to drawings for description of test bore drilling log results.

1.6 WARRANTY

A. Provide five (5) year warranty covering the entire installation for materials and workmanship. Warranty shall cover leaks and settlement due to improper backfilling or compaction.

1.7 UNIT PRICE

A. Contractor shall submit as part of his/her bid a unit price per well for additional wells (up to 10%) authorized by the Owner.

B. Contractor's Base Bid shall be based on the number and depth of wells described on the drawings.

1.8 DESIGN

A. A test bore and thermal conductivity test was performed at this site in Month/Year. A copy of the test report is available by request from the Owner.

1.9 PROTECTION

A. Protect trees, shrubs, lawns, rock outcropping, and other features remaining as a portion of final landscaping. Place excavated material from trench on hard surface area, heavy mil sheet plastic or sheet vinyl to minimize damage to grassed areas.

B. Protect benchmarks, existing structures, fences, sidewalks, paving, and curbs from equipment and vehicular traffic.

C. Protect above and below grade utilities that are to remain.

D. Protect excavations by shoring, bracing, sheet piling, underpinning, or other methods required to prevent cave-in or loose soil from falling into excavation.

E. Notify Architect/Engineer of unexpected subsurface conditions.

F. Protect bottom of excavations and soil adjacent to and beneath foundations from freezing.

G. Refer to Section 23 05 00 for other requirements.

PART 2 - PRODUCTS

2.1 PIPE

A. The pipe shall be PE4710 HDPE with a minimum cell classification of 345464C per ASTM D3350-93 and a DR11 (200 psig) rating for u-bends and header pipe two inches and smaller and a minimum of DR15.5 (139 psig) for header pipe greater than two inch in diameter. This pipe will carry a warranty of no less than 50 years. Submit written warranty on piping.

B. Each pipe shall be durably marked with the manufacturer's name, nominal size, pressure rating, relevant ASTM standards, cell classification number and date of manufacture.

C. All piping used for the U-bend heat exchanger (pipe located in borehole) will have factory hot-stamped lengths impressed on the side of the piping indicating the length of the heat exchanger at that point. The length stamp shall read zero on one end and the actual heat exchanger total length on the other end.

D. The vertical heat exchanger will have a factory fused one-piece U-bend with pipe lengths long enough to reach grade from the bottom of the bore. U-bends fabricated from two elbows are not permitted.

E. Approved pipe manufacturers are Chevron Phillips Driscoplex 5300, Vanguard, Plexco, Centennial Plastics.

2.2 FITTINGS

A. Pipe fittings shall meet the requirements of ASTM D2683 (for socket fusion fittings) or ASTM D3261 (for butt/saddle fusion fittings). Each fitting shall be identified with the manufacturer's name, nominal size, pressure rating, relevant ASTM standards, and date of manufacturer.

2.3 BENTONITE GROUT (THERMALLY ENHANCED)

A. Material: Thermally enhanced bentonite grout shall be used to seal and backfill each vertical u-bend well bore of the closed-loop ground heat exchanger to ensure proper thermal contact with the earth and to ensure the environmental integrity of each vertical bore column. The grouting material shall remain in a plastic state (moldable) throughout the life of the system and shall not generate heat during the hydration process. No other backfill material shall be accepted.

B. Thermal Conductivity: The thermal conductivity of the grouting compound must be 1.0 Btu/hr-ft-°F or greater.

C. Permeability: The grout mixture shall also have a maximum permeability rate of less than 6.9 x 10-8 cm/s as determined by using the "Falling-Head Method" (defined in the United States Army Corp of Engineers' Civil Engineering Manual No. EM 1110-2-1906, *"Laboratory Soils Testing"*) as recommended by the U.S. Environmental Protection Agency to ensure proper sealing. Permeability shall be verified by an independent lab, with a copy of the report being supplied upon request from the Architect/Engineer.

D. Packaging: Grouting materials shall be pre-manufactured and packaged prior to delivery to the site. If the grouting material supplier does not supply sand additive, Contractor shall obtain pre-approval from the Architect/Engineer prior to site use as a thermal enhancement additive.

E. Product: Grouting material shall be Black Hills Bentonite's Thermal Grout Select as supplied by GeoPro, Inc., Barotherm Gold by Baroid Industrial Drilling Products, or Cetco High TC Geothermal Grout.

2.4 WARNING TAPE

A. Provide warning tape above underground piping per the requirements of Section 23 05 53.

2.5 LOCATING WIRE

A. Provide locating wire around perimeter of borefield and supply and return piping to building.

2.6 FIELD LOCATION

A. Bore locations shall be confined to the area designated on the accompanying drawings. Bore locations to be individually surveyed after drilling is complete, but before horizontal trenching is done.

B. Permanent corner markers shall be provided at the four corners of the bore field. Place 18-inch square concrete paving stone flush with grade at each corner.

C. Provide detailed GPS coordinates of each corner.

D. Final bore locations are to be surveyed and GPS located.

PART 3 - EXECUTION

3.1 PREPARATION

A. Identify required lines, levels, contours, and datum.

B. Identify known underground, above ground, and aerial utilities. Stake and flag locations.

C. Notify the Owner and coordinate the removal and relocation of utilities. At the Owner's direction, the Contractor shall notify utility company to remove and relocate utilities.

3.2 DRILLING

A. The vertical boreholes will be drilled to a depth allowing complete insertion of the vertical heat exchanger to its specified depth. The maximum borehole diameter will be six inches. If a larger diameter is required, prior approval must be granted by the Design Architect/Engineer.

B. Refer to drilling log or obtain subsurface conditions from another source.

3.3 U-BEND HEAT EXCHANGER ASSEMBLY

A. The U-bend heat exchanger pipe shall be air fill pressurized to 100 psig to check for leaks before insertion. If necessary, an iron (sinker) bar can be attached at the base of each vertical heat exchanger u-bend to overcome buoyancy. This iron bar will have all sharp edges adequately taped to avoid scarring and/or cutting of the HDPE pipe. No driving rod that is pulled out after U-bend insertion will be allowed. The entire assembly shall be inserted to the specified depth in the borehole.

3.4 GROUTING PROCEDURES

A. The U-bend heat exchanger shall be pressure grouted from the bottom up to the ground surface in a continuous fashion using a one inch HDPE tremie pipe. The tremie pipe will be pulled out during the grouting procedure, maintaining the pipe's end just below grout level within the borehole. All state regulations will be met for borehole grouting of a vertical heat exchanger.

B. Slurry mixture and grouting process shall conform to "Grouting Procedures: As published by IGSHPA 1991."

C. All bore holes shall be grouted immediately after loop pipe installation. Bore hole grouting shall be monitored, and all grout quantities consumed shall be documented. Drill cuttings/chips shall not be used as grout or bore hole fill material. All voids, fractures, or highly permeable formations shall be noted on the well log, along with means used to stop grout loss/subsidence.

3.5 HEAT FUSION PIPE JOINING

A. All underground pipe joining shall be heat fused by socket, butt, or saddle (sidewall) fusion in accordance to ASTM D2610, ASTM D2683, and the manufacturer's heat fusion specifications. The operator shall be heat fusion certified and experienced in executing quality fusion joints.

3.6 EXCAVATION AND BACKFILLING FOR PIPING

A. General Requirements:

1. The Contractor shall do all excavating, backfilling, shoring, bailing, and pumping for the installation of their work and will perform necessary grading to prevent surface water from flowing into trenches or other excavations. Sewer lines shall not be used for draining trenches, and the end of all pipe and conduit shall be kept sealed and lines left clean and unobstructed during construction. Only material suitable for backfilling shall be piled a sufficient distance from banks of trenches to avoid overloading. Unsuitable backfill material shall be removed as directed by the Design Architect/Engineer.

2. Sheathing and shoring shall be done as necessary for protection of work and personnel safety. Unless otherwise indicated, excavation shall be open cut except for short sections. The Contractor shall install geothermal marking (warning) tape 18 inches above all horizontal/header piping.

3. Prior to drilling or trenching, the Contractor shall be responsible for reviewing the location of underground utilities with the Owner’s representative. Contractor shall arrange for utility marking. Existing utility lines uncovered during excavation shall be protected from damage during excavation and backfilling.

4. Stockpile and protect excavated material in area designated on site. Remove clean excess material not being reused to location on site designated by Owner. Remove from site excess excavated material not determined to be clean. Legally dispose of excess excavated material.

B. Excavation Requirements:

1. Underpin adjacent structures that will be damaged by excavation work, including utilities and pipe chases.

2. Excavate subsoil required to accommodate site structures, construction operations, and other work.

3. Machine slope banks to angle of repose or less, until shored.

4. Excavation cut not to interfere with normal 45 degree bearing splay of foundation, except where excavation support system is used.

5. Grade top perimeter of excavation to prevent surface water from draining into excavation.

6. Hand trim excavation. Remove loose matter.

7. Compaction should be 85% or higher.

8. Notify Architect/Engineer immediately of unexpected subsurface conditions.

3.7 PIPE INSTALLATION

A. The U-bend ends shall be sealed with fusion caps prior to insertion into the borehole. Reasonable care shall be taken to ensure the geothermal loop field pipe is not crushed, kinked, or cut. Should any pipe be damaged, the damaged section shall be cut out and the pipe reconnected by heat fusion.

B. The U-bend heat exchanger must be connected as indicated on the plans. The header design accounts for balanced flow, as well as flushing and purging flow rates. No variations can be made in the circuit hookup or the pipe sizes indicated. The minimum bend radius for each pipe size shall be 25 times the nominal pipe diameter or the pipe manufacturer's recommendations, whichever is greater. The depth of all headers and supply and return piping is indicated on the plans or must be maintained below the frost line.

C. Circuits shall be pressure tested before any backfilling of the header trenches is executed. The individual circuits shall be pressure tested with water at 100 psig; however, not to exceed 150% of SDR 11 pipe working pressure at bottom of vertical U-bend heat exchanger.

3.8 TESTING AND CLEANING

A. General Requirements:

1. During installation, all trash, soil, small animals, and other organic material shall be kept out of the pipe. Ends of the HDPE pipe shall be sealed until the pipe is joined to the circuits.

2. The Contractor shall be responsible for correcting any problems and/or paying for any damage caused by any debris left in the lines, after the flushing procedure has been completed, that enter the building and plug strainers or otherwise negatively impact the performance of the building systems.

B. Flushing and Purging:

1. Before backfilling the trenches, all systems shall be flushed and purged of air and flow tested to ensure all portions of the closed-loop ground heat exchanger are properly flowing. A portable temporary purging unit shall be used.

2. Each supply and return circuit shall be flushed and purged with a minimum water velocity of four feet per second. Flush until clean, including removal of all cuttings, shavings, mud, sand, and debris. The lines shall be left filled with clean water and then pressure tested. If connection to the manifold is not immediate, piping must be capped.

3. Utilizing the purging unit, conduct a pressure and flow test on the ground heat exchanger to ensure the system is free of blockage. If the flow test indicates blockage, locate blockage using manufacturer’s recommendation, remove blockage, then re-purge and conduct the pressure and flow test again until all portions of the system are flowing properly.

C. Hydrostatic Testing:

1. Fill and pressure test each piping circuit to 100 psig for four hours prior to the backfilling of the trenches.

2. Each joint shall be visually and physically inspected, using industry standards, for cold joints. Any joints failing the test shall be completely removed from the system and a new joint or fitting installed, with the test being repeated.

3. Correction of any piping leaks will be the responsibility of the Contractor who installed the piping. A second leak test will be required.

4. Before final connection of the plastic piping lines to the building system main supply and return loops, each circuit shall be flushed thoroughly and left filled with clean water.

D. Grout Testing:

1. The contractor, when directed by the owner or engineer, will take up to three (3) grout samples. Sampling will be spread apart (approximately first bore, sometime during first 1/3 and sometime during middle 1/3)). Contractor will pay for sampling costs, including shipping.

2. Grout samples will be mailed within 24 hours of being taken.

3. Results from grout samples will be provided within 24 hours of being received.

E. During piping installation, the Architect/Engineer has the option to test the depth of two holes at random. If the length is as specified, the piping may be tested and covered. If shorter than the length specified, the heat exchanger field or the individual heat exchanger must be increased as specified. In addition, all heat exchanger holes must be uncovered and have their lengths verified and vertical and horizontal tolerances verified. At the Owner Representative's option, the heat exchanger field will be required to be increased to the specified lengths or replaced.

END OF SECTION

SECTION 23 73 13
MODULAR AIR HANDLING UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Modular Indoor Air Handling Units.

1.2 QUALITY ASSURANCE

A. AHU Unit: Manufacturer specializing in design and manufacturing of the products specified in this section with a minimum of five years' experience.

B. Fabrication: Conform to AMCA 99 and AHRI 430.

C. Fan Performance Ratings: Conform to AMCA 210 and bear AMCA Certified Rating Seal.

D. Sound Ratings: Tested to AMCA 300.

E. Air Coils: Certify capacities, pressure drops, and selection procedures per AHRI 410.

F. Electrical control wiring shall be in accordance with NEC codes and ETL requirements.

G. Unit shall contain only UL listed components.

H. Conform to ASHRAE 90.1.

I. All air handling and distribution equipment mounted outdoors shall be designed to prevent rain intrusion into the airstream when tested at design airflow and with no airflow, using the rain test apparatus described in Section 58 of UL 1995.

1.3 SUBMITTALS

A. Submit shop drawings per Section 23 05 00. Indicate ratings, fan performance, motor electrical characteristics, gauges, material finishes, assembly, unit dimensions, weight loading, required clearances, construction details, and field connection details.

1. Product Data

a. Provide fan curves with specified operating point clearly plotted. Select fans using external static pressure noted in the schedule. Manufacturer responsible for calculation of internal static pressure. Manufacturer shall include an allowance for clean filters in the internal static pressure. An allowance for the difference between dirty filters and clean filters is included in the external static. Submit static pressure calculations showing total pressure drops, including tabulated internal pressure drops and specified external static pressure drops

b. Submit sound power level data for both fan outlet and casing radiation at rated capacity.

c. Submit shop drawings indicating coil and frame configurations, dimensions, materials, rows, connections, and rough-in dimensions

d. Submit manufacturer's data showing that coil capacities, pressure drops, and selection procedures meet or exceed specified requirements.

e. Provide a copy of data of filter media, filter performance data, filter assembly, and filter frames with unit submittal for reference only.

B. Submit manufacturer's installation instructions.

C. All base bid pricing shall be based on the drawings, schedules and this specification

1. If a manufacturer requests to deviate from the requirements described herein, the Manufacturer and/or Contractor may list voluntary add or deduct prices on the bid form. These voluntary prices will not be used in determining the low bidder.

2. All voluntary adds or deducts shall be discussed and agreed to by the Owner and Architect/Engineer prior to the award of the air handling unit bid and before the submittal process begins.

D. Any exceptions to the specifications must be clearly noted to the Architect/Engineer prior to acceptance. Contractor is responsible for all expenses due to exceptions.

E. Submit operation and maintenance data. Include instructions for lubrication, filter replacement, motor and drive replacement, and spare parts lists.

1.4 EXTRA STOCK

A. Provide clean filters in all units at time of installation.

B. Provide clean filters in all units at project final completion after all interior finishes are complete.

C. Provide one additional set of replacement filters for all units. Deliver to Owner at job site.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site with protective coverings in-place. Loose shipped items must be in factory-provided protective coverings, with factory-installed shipping skids and lifting lugs.

B. Store unit in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.6 WARRANTY

A. Provide a manufacturer’s 1-year parts and labor warranty against defects in material and workmanship.

1.7 GENERAL DESCRIPTION

A. Unit Location:

1. The unit will be set on a concrete housekeeping pad by the Contractor.

B. Unit Description:

1. The unit shall contain all the components described in these specifications and shown on the drawings and schedules.

2. Refer to air handling unit drawings and schedules for additional information

PART 2 - PRODUCTS

2.1 MODULAR INDOOR AIR HANDLING UNITS

A. Acceptable Manufacturers

1. Daikin
2. Carrier
3. Johnson Controls
4. Ventrol – ITF Indoor Unit

B. Housing:

1. WALL/ROOF CONSTRUCTION

a. Construct walls and roof from 2" thick double wall panel assemblies. Panels shall be injected with polyurethane foam insulation and shall have a minimum thermal conductivity (R) of at least 12.5. The outer shell shall be constructed of solid G90 galvanized steel with baked enamel or mill galvanized finish or G40 galvanized steel with gardobond finish. The inner liner shall be constructed of solid G90 galvanized steel or G40 galvanized steel with gardobond finish. Panels shall be gasketed with permanently applied bulb-type gaskets and able to be removed without affecting the integrity of casing structure.

b. Under 55°F supply air temperature and design conditions on the exterior of the unit of 91°F dry bulb and 74°F wet bulb, condensation shall not form on the casing exterior. The AHU manufacturer shall provide tested casing thermal performance for the scheduled supply air temperature plotted on a psychrometric chart. The design condition on the exterior of the unit shall also be plotted on the chart. If tested casing thermal data is not available, AHU manufacturer shall provide, in writing, a guarantee against condensation forming on the unit exterior at the stated design conditions above. The guarantee shall note that the AHU manufacturer will cover all expenses associated with modifying or replacing units should external condensate form on them.

c. Wall/Roof panel deflection shall not exceed L/240 ratio at a maximum +/- 5 inches of static pressure. Deflection shall be measured at the midpoint of the panel.

2. FLOOR CONSTRUCTION

a. Construct floors from 2" thick double wall panel assemblies. Panels shall be injected with polyurethane foam insulation and shall have a minimum thermal conductivity (R) of at least 12.5. The outer shell shall be constructed of solid G90 galvanized steel with baked enamel or mill galvanized finish or G40 galvanized steel with gardobond finish. The inner liner shall be constructed of solid G90 galvanized steel or G40 galvanized steel with gardobond finish. Panels shall be gasketed with permanently applied bulb-type gaskets.

b. Under 55°F supply air temperature and design conditions on the exterior of the unit of 91°F dry bulb and 74°F wet bulb, condensation shall not form on the casing exterior. The AHU manufacturer shall provide tested casing thermal performance for the scheduled supply air temperature plotted on a psychrometric chart. The design condition on the exterior of the unit shall also be plotted on the chart. If tested casing thermal data is not available, AHU manufacturer shall provide, in writing, a guarantee against condensation forming on the unit exterior at the stated design conditions above. The guarantee shall note that the AHU manufacturer will cover all expenses associated with modifying or replacing units should external condensate form on them.

c. Floor panel deflection shall not exceed L/240 ratio based upon a 300 lb concentrated load at the mid-span of the panel.

3. A full perimeter base rail shall be installed at each air handling unit. The base rail shall be constructed from a minimum of 16 gauge G90 galvanized steel and shall be at least 6" high. Panels shall be able to be removed without affecting the integrity of casing structure.

4. Install a stainless steel drain pan under each cooling coil meeting requirements as outlined in ASHRAE 62.1. Extend drain pans the entire width of each coil, including piping and header if in the air stream, and from the upstream face of each coil to a distance 1/2 of the vertical coil height downstream from the downstream face. Pitch drain pans in two directions towards the outlet, with a slope of at least 1/8" per foot.

5. Provide internal wiring for the installation of the lights and power for the lights and receptacles should be provided to a single point inlet power connection.

C. Doors:

1. Unit doors shall be double wall and insulated with the same materials used in the surrounding unit walls.

2. Doors shall contain a continuous neoprene bulb type gasket.

3. Each door shall contain a double pane tempered, reinforced or safety glass window.

4. Each door shall have a minimum of two (2) high compression type latches, operable from both sides.

5. Provide minimum 12" x 18" hinged access doors on both sides of the fan housing.

D. Access Sections:

1. Provide access sections as shown on the drawings between unit sections. Provide access doors as shown on plans.

E. Fan:

1. Double width, double inlet, airfoil centrifugal.

2. Fan RPM shall not exceed 110% of scheduled value with the scheduled wheel type. Substitution of BI or BIA fans for FC is acceptable if efficiency is not lower.

3. Statically and dynamically balanced.

4. Grease lubricated ball bearings, selected for 200,000 hours L-50 life at the design operating conditions.

5. Provide extended lubrication lines for all bearings to an easily accessible location.

6. Factory balanced fans will be used with variable speed controls to operate at all speeds up to the design speed.

7. Fan(s) shall have internal spring isolators.

F. Motors and Drives:

1. Motors shall have slide rails, adjusting screws, anchor bolts and bedplates.

2. Motor mounting bracket shall be adjustable to allow tightening of belts.

3. Motors shall be TEFC type with grease lubricated bearings.

4. Motors shall be "variable frequency drive rated" when controlled by VFDs. Refer to Section 23 05 13.

5. No equipment shall be selected or operate above 90% of its motor nameplate rating.

G. Enthalpy Wheel:

1. Refer to specification section 23 72 00 for requirements.

H. Coils

1. Glycol Water Coils:

a. Extended surface type with seamless copper tubes and continuous plate type aluminum fins.

b. Suitable for continuous operation at 200 psi. Maximum air velocity of 1000 fpm.

c. Galvanized steel casing. Coil headers and U-bends shall not be exposed.

d. AHRI rated with 0.0005 fouling factor.

e. Size coils sized based on EWT, EAT, gpmand cfm as scheduled. LAT shall be at least as high as scheduled. APD and WPD shall not exceed scheduled values.

f. Maximum 144 fins per foot.

g. Coils shall have drain and vent connections at supply and return headers with valves. Extend valving outside of the unit casing.

h. Install coils level to allow drainage.

i. Minimum 0.024" tube wall thickness.

j. Acceptable Manufacturers: Trane, York, Carrier, Marlo, Daikin/McQuay, Heatcraft, or American Air Filter.

2. Direct Expansion Coils:

a. Extended surface type with seamless copper tubes and continuous plate type aluminum fins.

b. Galvanized steel casing.

c. Suitable for 250 psig. Maximum air velocity of 500 fpm.

d. AHRI rated for direct expansion use with R-22.

e. Size coils based on saturated suction temperature, EAT and cfm scheduled. The leaving DB and APD shall not exceed the scheduled values.

f. Maximum 144 fins per foot. No water carryover shall occur at design airflow and no anti-carryover coating shall be used.

g. All coils shall be split row or intertwined configuration.

h. Minimum 0.016" tube wall thickness.

i. Acceptable Manufacturers: Trane, York, Heatcraft, or Daikin/McQuay.

I. Mixing and Filter Section

1. Provide an angle filter section for 4" thick filters. Maximum filter velocity shall not exceed specified value. Provide full size hinged access doors.

2. Reference Section 23 40 00 for filter requirements.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements

1. Install per manufacturer's instructions.

2. During construction provide temporary closures of metal or taped polyethylene over openings into housing ducts to prevent dust from entering ductwork.

3. Seal all contractor installed penetrations airtight. Seal all openings prior to cleaning. Seal holes with proper SMACNA closures conforming to pressure class of the housing.

4. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

B. Coil Requirements:

1. Comb all coils to repair bent fins.

2. Extend coil drain and vent connections to outside unit housing. Provide normally closed valve on drain and vent connection outside of unit housing.

END OF SECTION

SECTION 23 74 23.13
GAS FIRED MAKE-UP AIR UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Direct Fired Make-Up Air Unit.

1.2 QUALITY ASSURANCE

A. Comply with applicable regulations and have local Gas Company approval.

B. Factory test to check construction, controls, and operation of unit and provide certification.

C. Test operation after installation.

D. Provide with complete one (1) year warranty. Warranty period begins at date of initial startup.

E. Conform to ASHRAE 90.1.

F. All air handling and distribution equipment mounted outdoors shall be designed to prevent rain intrusion into the airstream when tested at design airflow and with no airflow, using the rain test apparatus described in Section 58 of UL 1995.

1.3 SUBMITTALS

A. Submit shop drawings per Section 23 05 00 showing dimensions, connections, arrangement, accessories, electrical service and duct connections, and controls.

B. Submit manufacturer's installation instructions.

C. Submit operation and maintenance data including manufacturer's descriptive literature, maintenance and repair data, and parts listing.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Protect units from physical damage by storing off-site until ready for installation.

PART 2 - PRODUCTS

2.1 DIRECT FIRED MAKE-UP AIR UNIT

A. Acceptable Manufacturers:

1. Greenheck.
2. Modine

B. Manufactured Units:

1. Self-contained direct-fired make-up air unit with burner, inlet damper, gas controls, unit controls, and all accessories noted or required for complete installation.

2. Units shall bear a UL, ETL or AGA label indicating that the units have been tested and comply with Standard ANSI Z83.4.

3. Suspended mounted inside building.

4. Unit to consist of direct-fired gas burner, unit cabinet and frame, direct drive supply fan, and all unit and burner safety and control devices.

5. Controls shall include terminal connections for setpoint adjustment and system enable/disable.

6. Furnish non-fused disconnect switch, short circuit protection of all internal electrical components, and all necessary motor starters, contactors, and over-current protection.

C. Fabrication:

1. Construct heater casing and components of 18 gauge steel panels, reinforced with angles and channels for rigidity. Provide access panels to burner and blower motor assemblies.

2. Locate port on burner section for observing main and pilot flames.

3. Insulate indoor units up to burner section with 1" thick neoprene faced glass fiber insulation.

4. Finish casing and components with heat resistant baked enamel.

D. Filters:

1. Provide filter section complete with removable 4" thick MERV 13 pleated filter. Refer to 23 40 00 for requirements.

E. Burner:

1. Provide natural gas burner with modulating turndown ratio of 30:1. Adjustable profile plate, stainless steel baffles, cast aluminum burner tube.

2. Gas Burner: Forced draft type burner with adjustable combustion air supply, pressure regulator, gas valves, manual shutoff, intermittent spark, flame sensing device, and automatic 100 percent shutoff pilot.

3. Gas Burner Safety Controls: Energize ignition, limit time for establishment of flame, prevent opening of gas valve until pilot flame is proven, stop gas flow on ignition failure, energize blower motor, and after airflow proven and slight delay, allow gas valve to open.

4. High Limit Control: Temperature sensor with fixed stop at maximum permissible setting, de-energize burner on excessive bonnet temperature and energize burner when temperature drops to lower safe value.

F. Fan:

1. Provide statically and dynamically balanced direct drive centrifugal fan. Extend any grease lines to access doors.

G. Unit Controls:

1. Pre-wire unit so connection of power supply and field wiring to unit's terminal strip makes unit operative. Wiring and control enclosures shall meet NEC and local codes. Provide pre-wired, numbered terminal strips for field wiring connections to Building Automation System.

2. Provide the following safety controls: air flow switch, electronic flame safety relay, high temperature limit switch, starter interlock, high gas pressure switch, low gas pressure switch, low discharge temperature control with bypass timer.

H. Gas Manifold:

1. Pilot line shall include: gas shutoff valve, gas regulator, pilot gas valve.

2. Main gas line shall include: gas shutoff valve, gas regulator, main gas valve (2 required), modulating gas valve, leakage test valve, low pressure gas switch, high pressure gas switch, vent valve between the two main gas valves and all required test valves.

3. Gas train shall meet FIA/IRI, local utility, and Owner's insurance company requirements.

4. Provide piping from vent valve to outside the building.

5. Provide additional regulator if the incoming gas pressure exceeds 2 psig.

6. Locate all valves and components in a unit mounted enclosure.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that area is ready to receive work and opening dimensions are as indicated on the shop drawings and illustrated by the manufacturer.

B. Verify that proper power supply is available.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. All field wiring shall be per the National Electrical Code.

3.3 MANUFACTURER'S FIELD SERVICES

A. Provide initial start-up and shutdown during first year of operation, including routine servicing and check-out.

END OF SECTION

SECTION 23 81 46
PACKAGED WATER SOURCE HEAT PUMPS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Water – to - Water.

1.2 QUALITY ASSURANCE

A. Fan Performance Ratings: Conform to AMCA 210 and bear the AMCA Certified Rating Seal.

B. Fabrication: Conform to AMCA 99, ARI 320 and /or ARI 340.

C. Air Coils: Certify capacities, pressure drops, and selection procedures in accordance with ARI 410.

D. Water Source Heat Pumps: Product of manufacturer regularly engaged in production of components who issue complete catalog data on total product.

E. Conform to ASHRAE 90.1.

1.3 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 23 05 00.

B. Shop drawings shall indicate assembly, unit dimensions, weight loading, required clearances, construction details, and field connection details.

C. Product and data shall indicate capacities, ratings, fan performance, motor electrical characteristics, and gauges and finishes of materials.

D. Provide fan curves with specified operating point clearly plotted.

E. Submit manufacturer's installation instructions.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site in factory fabricated protective containers with factory installed shipping skids and lifting lugs.

B. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data.

B. Include instructions for lubrication, filter replacement, motor and drive replacement, and spare parts list.

1.6 ENVIRONMENTAL REQUIREMENTS

A. Do not operate units for any purpose, temporary or permanent, until filters are in place, bearings lubricated, and fan has been test run under observation.

1.7 WARRANTY

A. Provide one (1) year manufacturer's warranty on all components of heat pump.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Multistack (Heatstack)
B. Climacool
C. Aaon

2.2 WATER – TO - WATER

A. General:

1. Equipment shall be completely factory assembled and tested, piped, internally wired, and fully charged with R-410A. Field interface terminal strip and all safety controls shall be furnished and factory installed.

2. Capacities shall be rated in accordance with ARI 320. Equipment shall be UL or ETL approved.

3. All water source heat pumps shall be high efficiency type.

4. All units shall be factory run and tested for proper operation.

5. Unit shall include flow switches and two way head pressure control.

B. Housing:

1. 18-gauge steel construction with baked on enamel finish. 1/2", 1-1/2 lb. density interior insulation.

2. Access panels for compressor and control compartments.

3. Knockouts for entrance of line voltage and control wiring, all wiring connections shall be made internal to the unit.

4. Supply and return water connections shall be FPT fittings and shall protrude through the cabinet for connection to flexible hose.

5. Metal bracket, Isolators, and fasteners to suspend unit from building structure.

6. Unit size and capacity shall be as scheduled on the drawings.

C. Refrigerant Circuit:

1. Unit shall be ARI rated and ETL and CSA listed. Each unit shall be fully run tested at the factory with a copy of the run test report furnished with operation and maintenance manuals.

2. Each unit shall have a sealed refrigerant circuit including digital scroll type hermetic compressors, capillary expansion tubes, water to refrigerant coaxial heat exchanger and safety controls to include low suction temperature, high and low pressure switches. Safety controls shall be resettable from the main disconnect only.

3. Compressor shall be digital scroll type hermetic type, spring isolated for maximum sound and vibration isolation, and have thermal overload protection.

4. UL listed coaxial heat exchanger constructed of copper inner tube and galvanized steel outer tube.

5. Unit shall accept time delay fuses or HACR circuit breaker for branch over-current protection.

6. The use of chlorofluorocarbon (CFC)-based refrigerants is prohibited.

D. Electrical:

1. Disconnect provided by Electrical Contractor.

2. Unit electrical characteristics shall be as scheduled on the drawings. Provide transformers as required for control power.

E. Controls

1. Unit shall have a low-voltage terminal strip for hardwire connection to the DDC system. Unit shall include internal safety controls for compressor short cycle protection, brown out protection, and compressor time delay. The DDC system will control the unit operation as detailed on the mechanical drawings.

2.3 WATER – TO - REFRIGERANT

A. General:

1. Equipment shall be completely factory assembled and tested, piped, internally wired, and fully charged with R-410A. Field interface terminal strip and all safety controls shall be furnished and factory installed.

2. Capacities shall be rated in accordance with ARI 320. Equipment shall be UL or ETL approved.

3. All water source heat pumps shall be high efficiency type.

4. All units shall be factory run and tested for proper operation.

5. Unit shall include balancing valves, water flow switch, and two way head pressure control.

B. Housing:

1. 18-gauge steel construction with baked on enamel finish. 1/2", 1-1/2 lb. density interior insulation.

2. Access panels for compressor and control compartments.

3. Knockouts for entrance of line voltage and control wiring, all wiring connections shall be made internal to the unit.

4. Supply and return water connections shall be FPT fittings and shall protrude through the cabinet for connection to flexible hose.

5. Metal bracket, Isolators, and fasteners to suspend unit from building structure.

6. Unit size and capacity shall be as scheduled on the drawings.

C. Refrigerant Circuit:

1. Unit shall be ARI rated and ETL and CSA listed. Each unit shall be fully run tested at the factory with a copy of the run test report furnished with operation and maintenance manuals.

2. Each unit shall have a sealed refrigerant circuit including digital scroll type hermetic compressors, capillary expansion tubes, water to refrigerant coaxial heat exchanger and safety controls to include low suction temperature, high and low pressure switches. Safety controls shall be resettable from the main disconnect only.

3. Compressor shall be digital scroll type hermetic type, spring isolated for maximum sound and vibration isolation, and have thermal overload protection.

4. UL listed coaxial heat exchanger constructed of copper inner tube and galvanized steel outer tube.

5. Unit shall accept time delay fuses or HACR circuit breaker for branch over-current protection.

6. The use of chlorofluorocarbon (CFC)-based refrigerants is prohibited.

D. Electrical:

3. Disconnect provided by Electrical Contractor.

4. Unit electrical characteristics shall be as scheduled on the drawings. Provide transformers as required for control power.

E. Controls

1. Unit shall have a low-voltage terminal strip for hardwire connection to the DDC system. Unit shall include internal safety controls for compressor short cycle protection, brown out protection, and compressor time delay. The DDC system will control the unit operation as detailed on the mechanical drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Protect units with protective cover during construction.

3.2 CLEANING

A. After construction is completed, including painting, clean exposed surfaces of units. Clean coils and inside of units by vacuuming.

END OF SECTION

SECTION 23 82 00
TERMINAL HEAT TRANSFER UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Panel Radiation.
B. Unit Heaters.
C. Cabinet Heaters.

1.2 QUALITY ASSURANCE

A. Factory wired equipment shall conform to ANSI/NFPA 70.

1.3 REFERENCES

A. ANSI/ASHRAE 62.1 - Ventilation for Acceptable Indoor Air Quality.

B. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.

C. ANSI/NFPA 70 - National Electrical Code.

1.4 SUBMITTALS

A. Submit shop drawings per Section 23 05 00.

B. Submit catalog data including arrangements, cross sections of cabinets, grilles, bracing, typical elevations.

C. Submit schedules of equipment and enclosures indicating length, number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, and comparison of specified to actual heat output.

D. Indicate mechanical and electrical service locations and requirements. Show deviations from scheduled products.

E. Submit manufacturers' installation instructions.

1.5 DELIVERY, STORAGE AND HANDLING

A. Protect units from physical damage by storing in protected areas and leaving factory covers in place.

1.6 REGULATORY REQUIREMENTS

A. Conform to ASHRAE 90.1.

1.7 OPERATION AND MAINTENANCE DATA

A. Submit manufacturer's operation and maintenance data. Include operating, installation, maintenance and repair data, and parts listings.

PART 2 - PRODUCTS

2.1 PANEL RADIATION - WALL HUNG

A. All components shall be steel.

B. With corrugated fins welded to flat horizontal tubes to connect to vertical headers at each end.

C. Headers with inlet, outlet, vent and drain connections, and baffles for even heat distribution.

D. Provide integral all-welded perforated top grille.

E. Rated for 85 psi working and 110 psi test pressure.

F. Rated per ISO 1503147-3150.

G. Units to have gloss powder-coated finish. Color selection by the Architect. Furnish color charts with shop drawings.

H. Install mounting hardware per manufacturer's recommendations. Conceal all mounting hardware.

I. Acceptable Manufacturer: Runtal, Rittling, Vulcan, Sterling.

2.2 UNIT HEATERS

A. Casings shall be heavy gauge steel with a baked finish.

B. Coils shall have copper heads and tubes, and aluminum fins.

C. Units shall have threaded pipe connections for hanger rods.

D. Fans shall be direct drive propeller type, factory balanced, with fan guards and totally enclosed motors with integral thermal overload protection.

E. Horizontal units shall have adjustable outlet air louvers.

F. Provide unit mounted and wired disconnects. Contractor shall be responsible for providing and wiring disconnect when using a manufacturer who does not provide factory mounted option.

G. Acceptable Products: Trane - S or P, Daikin/McQuay - UHH or UDH, Modine - HS or V, Vulcan - HV or VV, Sterling HS or VS, Rittling - H or V, Sigma H or V, Airtherm HA or VA.

2.3 HOT WATER CABINET HEATERS

A. Units shall include cabinet, fan, motor, coil, filter, inlet grille and discharge grille.

B. Cabinets: 16 gauge exposed surfaces and 18 gauge concealed surfaces. Plastic exposed parts are not acceptable.

C. Baked enamel finish. Color selected by Architect.

D. All motors shall be three-speed permanent split capacitor with integral thermal overload protection.

E. Coils shall have finned copper tubes.

F. Provide 1" thick disposable filters or 1/2” thick washable 65% aluminum filters ahead of all coils.

G. Provide a concealed unit mounted fan switch with "Off-High-Medium-Low" positions that doubles as disconnect.

H. Acceptable Manufacturers: Trane - 'Force-Flo', Sterling, Modine, Rittling, Sigma, Vulcan, Airtherm, Beacon Morris.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install all products per manufacturers' instructions.
2. Coordinate recess sizes for recessed equipment.
3. Protect units with protective covers during construction.
4. Comb all coils to repair bent fins.

B. Panel Radiation:

1. Locate finned tube radiation as shown and run cover wall-to-wall, unless otherwise shown. Center elements under windows.

C. Unit Heater:

1. Hang unit heaters from building structure, not from piping. Mount as high as possible within manufacturer's recommended mounting height requirements. If unit heaters cannot be installed within manufacturer's recommended range, notify Architect/Engineer prior to mounting.

3.2 CLEANING

A. After construction is complete, 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, with materials furnished by manufacturer.

C. Install new filters.

END OF SECTION

SECTION 23 83 00
RADIANT FLOOR HEATING SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Description:

1. Furnish and install radiant floor heating system tubing, distribution manifolds, manifold support brackets, manifold to tubing fittings, manifold end caps and bushings, circuit isolation and balancing valves, controls, and installation specialties, supervision and field engineering required for complete and proper function of the system.

B. System Design:

1. Provide a system as zoned per equipment schedule.

1.2 REFERENCES

A. ASTM F876 - Standard Specification for Cross-Linked Polyethylene (PEX) Tubing.

B. ASTM F877 - Cross-Linked Polyethylene (PEX) Plastic Hot and Cold Water Distribution Systems.

C. CAN/CSA-B137.5 - Cross-Linked Polyethylene (PEX) Tubing Systems for Pressure Applications.

D. DIN 4726 - German Standard for Plastic Piping used in Warm Water Floor Heating Systems.

1.3 SUBMITTALS

A. Provide submittals and shop drawings in accordance with the General Requirements and as specified herein.

B. Submit shop drawings indicating detailed layout of system, including equipment, tubing locations, loop lengths, critical dimensions, tubing/slab penetration details, fittings, and details for protected exposed PEX tubing. Provide pressure drops at design flow rates for all equipment including loops, manifolds, isolation valves, and control valves. Provide detailed flow, pressure, and electrical power requirements of radiant system pump.

C. Submit manufacturer's technical instructions including specific installation instructions for system installation in the specific construction of the radiant panel or slab. Include details at slab construction joints and expansion joints.

D. Submit installer’s certifications of training for installation of PEX floor heating systems.

E. Submit data indicating tube sizing and panel performance at tube spacing and warm water temperatures selected.

F. Submit independent certification results for the tubing systems from a recognized testing laboratory.

G. Submit catalog data on all supports, tube guides, spacers, fittings, and associated items necessary for the installation of the tubing and manifolds.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store tubing and specialties in shipping containers with labeling in place. Do not expose to ultraviolet light for more than 90 days.

B. Protect tubing and specialties from entry of contaminating material by installing tape or plugs in all open tube ends until installation and/or maintain tubing in the original shipping boxes or packaging until usage.

C. Unprotected tubes shall not be dragged across the ground or concrete surfaces, and shall be stored on a flat surface with no sharp edges.

D. Tube shall be protected from oil, grease, direct sunlight, paint, and other elements as recommended by manufacturer.

1.5 REGULATORY REQUIREMENTS

A. Tubing shall conform to ASTM F876 and ASTM F877 (for Canada conform to CAN/CSA B137.5). Tubing oxygen permeation barrier shall conform to DIN 4726.

B. Installer's Qualification: Installer's shall be qualified, in writing, as either being certified or certifiable prior to the commencement of the installation.

1.6 WARRANTY

A. The radiant floor system component manufacturer shall warrant the tubing to be free from defects in material and workmanship for a period of twenty-five (25) years.

B. All manifolds, pumps, and controls shall be warranted for 18 months and/or two heating seasons.

PART 2 - PRODUCTS

2.1 SYSTEM COMPONENTS

A. Tube:

1. Tube shall be cross-linked polyethylene, aluminum core polyethylene, or multi-layer, elastomeric, industrial grade EPDM rubber hose with maximum working pressure/temperature of 160 psi @ 73.4ºF, 100 psi @ 180ºF, 80 psi @ 200ºF.

2. The tube shall be manufactured in accordance with ASTM standard specification F876. The tube shall be listed to ASTM by independent third party testing laboratory.

3. The tube shall be of cross-linked polyethylene with a minimum degree of cross-linking of 80% or multi-layer, elastomeric, industrial grade EPDM rubber hose. The tube shall have an oxygen diffusion barrier capable of limiting oxygen diffusion through the tube to no greater than 0.10g/m^3/day @ 104ºF water temperature.

4. The tube dimensions shall be: 5/8" nominal inside diameter or 3/4” nominal inside diameter in accordance with ASTM standard specification, as pertaining to paragraph 2.

5. The minimum bend radius for cold bending of the tube shall not be less than six (6) times the outside diameter. Bends with a radius less than stated shall require the use of a bend support as supplied by the tube manufacturer.

6. All Components: Components of the buried tubing system shall be provided by one manufacturer, including; tube, fittings, manifolds, controls, and other ancillary items required for a complete installation.

B. Manifolds:

1. Manifolds shall be of cast brass construction, manufactured of alloys to prevent dezincification, and shall have integral circuit balancing valves. Manifolds shall be able to vent air from the system, and shall be provided with support brackets and tube bend supports. Manifolds shall be isolated from supply and return tubing with valves that are suitable for isolation and balancing.

C. Fittings:

1. Fittings shall be manufactured of dezincification resistant brass. These fittings must be supplied by the tube manufacturer. The fittings shall consist of a compression fitting with insert, compression ring and a compression nut.

D. Supply And Return Piping To Manifolds:

1. Piping shall be metal pipe or cross-linked polyethylene tube with an integral oxygen diffusion barrier. Cross-linked polyethylene tube should only be used when specifically approved by the local building inspector for supply and return piping applications.

2. Fittings shall be compatible to the piping material used. Fittings used with the cross-linked polyethylene tube shall not permit excessive oxygen permeation.

E. Acceptable Manufacturers: Roth, Uponor, Rehau, Kitec, Zurn,

PART 3 - EXECUTION

3.1 INSTALLATION

A. Hydronic radiant heat tubing loops shall be installed in accordance with the manufacturer's recommendations and the details as shown on the contract drawings.

B. All fittings should be accessible for maintenance. Tubing loops shall be installed without splices, as a minimum, from the point at which the tubing enters the panel to the point at which it exits the panel. No splices shall occur underground.

C. Installation shall follow the shop drawings for tubing layout, tube spacing, manifold configuration, manifold location, and controls. All notes on the drawing shall be followed.

1. The tubing system shall be pressurized, with water or air, in accordance, with applicable codes, or to a pressure of 60 psig 24 hours prior to encasement in the radiant panel. The tubing system shall remain at this pressure during the panel installation, and for a minimum of 24 hours thereafter to ensure system integrity. The Contractor shall provide the water or air for the pressurization of the tubing system. The Contractor assumes all liabilities for suitable safety precautions and testing, including the use of compressed air, when applicable.

2. Contractor shall take detailed photographs of installation and provide to owner as part of record documents in digital format for future reference.

D. At start up time, the Contractor shall: follow the manufacturer's recommendations for system water and temperature balancing, record balance settings at each manifold location, and deliver to the Owner a complete record of these settings for inclusion in the operation and maintenance manuals.

E. Any deviations from shop drawing layout must be accurately dimensioned for Owner's records.

F. Provide warning labels in mechanical equipment spaces to alert future building remodelers of the presence of in-slab tubing.

END OF SECTION

SECTION 26 05 00
BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Requirements applicable to all Division 26 Sections. Also refer to Division 1 - General Requirements. This section is also applicable to Interior Communications Pathways Section 27 05 28. This section is also applicable to Fire Alarm and Detection Systems Section 28 31 00.

B. All materials and installation methods shall conform to the applicable standards, guidelines and codes referenced in each specification section.

1.2 REFERENCES

A. NFPA 70 - National Electrical Code (NEC)

1.3 SCOPE OF WORK

A. This Specification and the associated drawings govern furnishing, installing, testing and placing into satisfactory operation the Electrical Systems.

B. The Contractor shall furnish and install all new materials as indicated on the drawings, and/or in these specifications, and all items required to make his portion of the Electrical Work a finished and working system.

C. Description of Systems shall be as follows:

1. Electrical power system to and including light fixtures, equipment, motors, devices, etc.
2. Electrical power service system from the Utility Company to and including service entrance equipment, distribution and metering.
3. Grounding system.
4. Fire alarm system.
5. Public address and intercom system.
6. Clock and program system.
7. Security system.
8. Wiring system for temperature control system as shown on the drawings.
9. Wiring of equipment furnished by others.
10. Removal work and/or relocation and reuse of existing systems and equipment.
11. Technology Systems as described in Division 27/28 and on the T-series documents as described in the Suggested Matrix of Scope Responsibility.

D. Work Not Included:

1. Telecommunications cabling will be by others, in raceways and conduits furnished and installed as part of the Electrical work.

2. Temperature control wiring for plumbing and HVAC equipment (unless otherwise indicated) will be by other Contractors.

1.4 OWNER FURNISHED PRODUCTS

A. The Owner will supply manufacturer's installation data for new equipment purchased by him for this project.

B. This Contractor shall make all electrical system connections shown on the drawings **or** required for fully functional units.

C. This Contractor is responsible for all damage to Owner furnished equipment caused during installation.

1.5 DIVISION OF WORK BETWEEN MECHANICAL, ELECTRICAL, AND CONTROL CONTRACTORS

A. Division of work is the responsibility of the Prime Contractor. Any scope of work described at any location on the contract document shall be sufficient for including said requirement in the project. The Prime Contractor shall be solely responsible for determining the appropriate subcontractor for the described scope. In no case shall the project be assessed an additional cost for scope that is described on the contract documents on bid day. The following division of responsibility is a guideline based on typical industry practice.

B. Definitions:

1. "Mechanical Contractors" refers to the Contractors listed in Division 21/22/23 of this Specification.

2. “Technology Contractors” refers to the Contractors furnishing and installing systems listed in Division 27/28 of this Specification.

3. Motor Power Wiring: The single phase or 3 phase wiring extending from the power source (transformer, panelboard, feeder circuits, etc.) through disconnect switches and motor controllers to, and including the connections to the terminals of the motor.

4. Motor Control Wiring: The wiring associated with the remote operation of the magnetic coils of magnetic motor starters or relays, or the wiring that permits direct cycling of motors by means of devices in series with the motor power wiring. In the latter case, the devices are usually single phase, have "Manual-Off-Auto" provisions, and are usually connected into the motor power wiring through a manual motor starter.

5. Control devices such as start-stop push buttons, thermostats, pressure switches, flow switches, relays, etc., generally represent the types of equipment associated with motor control wiring.

6. Motor control wiring is single phase and usually 120 volts. In some instances, the voltage will be the same as the motor power wiring. When the motor power wiring exceeds 120 volts, a control transformer is usually used to give a control voltage of 120 volts.

7. Temperature Control Wiring: The wiring associated with the operation of a motorized damper, solenoid valve or motorized valve, etc., either modulating or two-position, as opposed to wiring that directly powers or controls a motor used to drive equipment such as fans, pumps, etc. This wiring will be from a 120 volt source and may continue as 120 volt, or be reduced in voltage (24 volt), in which case a control transformer shall be furnished as part of the temperature control wiring.

8. Control Motor: An electric device used to operate dampers, valves, etc. It may be two-position or modulating. Conventional characteristics of such a motor are 24 volts, 60 cycles, 1 phase, although other voltages may be encountered.

9. Low Voltage Technology Wiring: The wiring associated with the Technology Systems, used for analog or digital signals between equipment.

10. Telecommunications Rough-in: Relates specifically to the backboxes, necessary plaster rings and other miscellaneous hardware required for the installation or mounting of telecommunications information outlets.

C. General:

1. The purpose of these Specifications is to outline the Electrical and Mechanical Contractors' responsibilities related to electrical work required for items such as temperature controls, mechanical equipment, fans, chillers, compressors, etc. The exact wiring requirements for much of the equipment cannot be determined until the systems have been selected and submittals approved. Therefore, the electrical drawings show only known wiring related to such items. All wiring not shown on the electrical drawings, but required for mechanical systems, is the responsibility of the Mechanical Contractor.

2. Where the drawings require the Electrical Contractor to wire between equipment furnished by the Mechanical Contractor, such wiring shall terminate at terminals provided in the equipment. The Mechanical Contractor shall furnish complete wiring diagrams and supervision to the Electrical Contractor and designate the terminal numbers for correct wiring.

3. The Electrical Contractor shall establish electrical utility elevations prior to fabrication and installation. The Electrical Contractor shall coordinate utility elevations with other trades. When a conflict arises, priority shall be as follows:

   a. Lighting Fixtures
   b. Gravity flow piping, including steam and condensate.
   c. Electrical bus duct.
   d. Sheet metal.
   e. Cable trays, including access space.
   f. Other piping.
   g. Conduits and wireway.

D. Mechanical Contractor's Responsibility:

1. Assumes responsibility for internal wiring of all equipment furnished by the Mechanical Contractor.

2. Assumes all responsibility for miscellaneous items furnished by the Mechanical Contractor that require wiring but are not shown on the electrical drawings or specified in the Electrical Specification. If items such as relays, flow switches, or interlocks are required to make the mechanical system function correctly or are required by the manufacturer, they are the responsibility of the Mechanical Contractor.

3. Assumes all responsibility for Temperature Control wiring, if the Temperature Control Contractor is a Subcontractor to the Mechanical Contractor.

4. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

E. Temperature Control Contractor's or Subcontractor's Responsibility:

1. Wiring of all devices needed to make the Temperature Control System functional.

2. Verifying any control wiring on the electrical drawings as being by the Electrical Contractor. All wiring required for the Control System, but not shown on the electrical drawings, is the responsibility of the Temperature Control Contractor or Subcontractor.

3. Coordinating equipment locations (such as PE's, EP's, relays, transformers, etc.) with the Electrical Contractor, where wiring of the equipment is by the Electrical Contractor.

F. Electrical Contractor's Responsibility:

1. Furnishes and installs all combination starters, manual starters and disconnect devices shown on the Electrical Drawings or indicated to be by the Electrical Contractor in the Mechanical Drawings or Specifications.

2. Installs and wires all remote control devices furnished by the Mechanical Contractor or Temperature Control Contractor when so noted on the Electrical Drawings.

3. Furnishes and installs motor control and temperature control wiring, when noted on the drawings.

4. Furnishes, installs, and connects all relays, etc., for automatic shutdown of certain mechanical equipment (supply fans, exhaust fans, etc.) upon actuation of the Fire Alarm System.

5. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

G. General (Electrical/Technology):

1. "Electrical Contractor" as referred to herein shall be responsible for scope listed in Division 27/28 of this specification when the "Suggested Matrix of Scope Responsibility" indicated work shall be furnished and installed by the EC. Refer to the Contract Documents for this "Suggested Matrix of Scope Responsibility".

2. The purpose of these Specifications is to outline the Electrical and Technology Contractor's work responsibilities as related to Telecommunications Rough-in, conduit, cable tray, power wiring and Low Voltage Technology Wiring.

3. The exact wiring requirements for much of the equipment cannot be determined until the systems have been purchased and submittals approved. Therefore, only known wiring, conduits, raceways and electrical power related to such items is shown on the Technology drawings. Other wiring, conduits, raceways, junction boxes and electrical power not shown on the Technology Drawings but required for operation of the systems is the responsibility of the Technology Contractor and included in said Contractor's bid.

4. Where the Electrical Contractor is required to install conduit, conduit sleeves and/or power connections in support of Technology systems, the final installation shall not be until a coordination meeting between the Electrical Contractor and the Technology Contractor has convened to determine the exact location and requirements of the installation.

5. Where the Electrical Contractor is required to install cable tray that will contain Low Voltage Technology Wiring, installation shall not begin prior to a coordination review of the cable tray shop drawings by the Technology Contractor.

H. Technology Contractor's Responsibility:

1. Assumes all responsibility for the Low Voltage Technology Wiring of all systems, including cable support where open cable is specified.

2. Assumes all responsibility for all required backboxes, conduit and power connections not specifically shown as being furnished and installed by the Electrical Contractor on the "Suggested Matrix of Scope Responsibility".

3. Assumes all responsibility for providing and installing all ladder rack and other cable management hardware (as defined herein).

4. Responsible for providing the Electrical Contractor with the required grounding lugs or other hardware for each piece of Technology equipment which is required to be bonded to the telecommunications ground bar.

5. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

1.6 COORDINATION DRAWINGS

A. Definitions:

1. Coordination Drawings: A compilation of the pertinent layout and system drawings that show the sizes and locations, including elevations, of system components and required access areas to ensure that no two objects will occupy the same space.

a. Mechanical trades shall include, but are not limited to, mechanical equipment, ductwork, fire protection systems, plumbing piping, medical gas systems, hydronic piping, steam and steam condensate piping, and any item that may impact coordination with other disciplines.

b. Electrical trades shall include, but are not limited to, electrical equipment, conduit 1.5" and larger, conduit racks, cable trays, pull boxes, transformers, raceway, busway, lighting, ceiling-mounted devices, and any item that may impact coordination with other disciplines.

c. Technology trades shall include, but are not limited to, technology equipment, racks, conduit 1.5" and larger, conduit racks, cable trays, ladder rack, pull boxes, raceway, ceiling-mounted devices, and any item that may impact coordination with other disciplines.

d. Maintenance clearances and code-required dedicated space shall be included.

e. The coordination drawings shall include all underground, underfloor, in-floor, in chase, and vertical trade items.

2. The contractors shall use the coordination process to identify the proper sequence of installation of all utilities above ceilings and in other congested areas, to ensure an orderly and coordinated end result, and to provide adequate access for service and maintenance.

B. Participation:

1. The contractors and subcontractors responsible for work defined above shall participate in the coordination drawing process.

2. One contractor shall be designated as the Coordinating Contractor for purposes of preparing a complete set of composite electronic CAD coordination drawings that include all applicable trades, and for coordinating the activities related to this process. The Coordinating Contractor for this project shall be the Mechanical Contractor.

a. The Coordinating Contractor shall utilize personnel familiar with requirements of this project and skilled as draftspersons/CAD operators, competent to prepare the required coordination drawings.

3. Electronic CAD drawings shall be submitted to the Coordinating Contractor for addition of work by other trades. IMEG will provide electronic file copies of ventilation drawings for contractor's use if the contractor signs and returns an "Electronic File Transfer" waiver provided by IMEG. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings.

C. Drawing Requirements:

1. The file format and file naming convention shall be coordinated with and agreed to by all contractors participating in the coordination process and the Owner.

a. Scale of drawings:

1) General plans: 1/4 Inch = 1 '-0" (minimum).

2) Mechanical, electrical, communication rooms, and including the surrounding areas within 10 feet: 1/2 Inch = 1'-0" (minimum).

3) Shafts and risers: 1/2 Inch = 1'-0" (minimum).

4) Sections of shafts and mechanical and electrical equipment rooms: 1/4 Inch = 1 '-0" (minimum).

5) Sections of congested areas: 1/2 Inch = 1'-0" (minimum).

2. Ductwork layout drawings shall be the baseline system for other components. Ductwork layout drawings shall be modified to accommodate other components as the coordination process progresses.

3. There may be more drawings required for risers, top and bottom levels of mechanical rooms, and shafts.

4. The minimum quantity of drawings will be established at the first coordination meeting and sent to the A/E for review. Additional drawings may be required if other areas of congestion are discovered during the coordination process.

D. General:

1. Coordination drawing files shall be made available to the A/E and Owner's Representative. The A/E will only review identified conflicts and give an opinion, but will not perform as a coordinator.

2. A plotted set of coordination drawings shall be available at the project site.

3. Coordination drawings are not shop drawings and shall not be submitted as such.

4. The contract drawings are schematic in nature and do not show every fitting and appurtenance for each utility. Each contractor is expected to have included in his/her bid sufficient fittings, material, and labor to allow for adjustments in routing of utilities made necessary by the coordination process and to provide a complete and functional system.

5. The contractors will not be allowed additional costs or time extensions due to participation in the coordination process.

6. The contractors will not be allowed additional costs or time extensions for additional fittings, reroutings or changes of duct size, that are essentially equivalent sizes to those shown on the drawings and determined necessary through the coordination process.

7. The A/E reserves the right to determine space priority of equipment in the event of spatial conflicts or interference between equipment, piping, conduit, ducts, and equipment provided by the trades.

8. Changes to the contract documents that are necessary for systems installation and coordination shall be brought to the attention of the A/E.

9. Access panels shall preferably occur only in gypsum board walls or plaster ceilings where indicated on the drawings.

   a. Access to mechanical, electrical, technology, and other items located above the ceiling shall be through accessible lay-in ceiling tile areas.

   b. Potential layout changes shall be made to avoid additional access panels.

   c. Additional access panels shall not be allowed without written approval from the A/E at the coordination drawing stage.

   d. Providing additional access panels shall be considered after other alternatives are reviewed and discarded by the A/E and the Owner's Representative.

   e. When additional access panels are required, they shall be provided without additional cost to the Owner.

10. Complete the coordination drawing process and obtain sign off of the drawings by all contractors prior to installing any of the components.

11. Conflicts that result after the coordination drawings are signed off shall be the responsibility of the contractor or subcontractor who did not properly identify their work requirements, or installed their work without proper coordination.

12. Updated coordination drawings that reflect as-built conditions may be used as record documents.

1.7 QUALITY ASSURANCE

A. Contractor’s Responsibility Prior to Submitting Pricing/Bid Data:

1. The Contractor is responsible for constructing complete and operating systems. The Contractor acknowledges and understands that the Contract Documents are a two-dimensional representation of a three-dimensional object, subject to human interpretation. This representation may include imperfect data, interpreted codes, utility guides, three-dimensional conflicts, and required field coordination items. Such deficiencies can be corrected when identified prior to ordering material and starting installation. The Contractor agrees to carefully study and compare the individual Contract Documents and report at once in writing to the Architect/Engineer any deficiencies the Contractor may discover. The Contractor further agrees to require each subcontractor to likewise study the documents and report at once any deficiencies discovered.

2. The Contractor shall resolve all reported deficiencies with the Architect/Engineer prior to awarding any subcontracts, ordering material, or starting any work with the Contractor’s own employees. Any work performed prior to receipt of instructions from the Architect/Engineer will be done at the Contractor’s risk.

B. Qualifications:

1. Only products of reputable manufacturers as determined by the Architect/Engineer are acceptable.

2. All Contractors and subcontractors shall employ only workmen who are skilled in their trades. At all times, the number of apprentices at the job site shall be less than or equal to the number of journeymen at the job site.

C. Compliance with Codes, Laws, Ordinances:

1. Conform to all requirements of the City of Madison, Wisconsin Codes, Laws, Ordinances and other regulations having jurisdiction over this installation.

2. If there is a discrepancy between the codes and regulations and these specifications, the Architect/Engineer shall determine the method or equipment used.

3. If the Contractor notes, at the time of bidding, any parts of the drawings or specifications that do not comply with the codes or regulations, he shall inform the Architect/Engineer in writing, requesting a clarification. If there is insufficient time for this procedure, he shall submit with his proposal a separate price to make the system comply with the codes and regulations.

4. All changes to the system made after the letting of the contract to comply with codes or the requirements of the Inspector, shall be made by the Contractor without cost to the Owner.

5. If there is a discrepancy between manufacturer's recommendations and these specifications, the manufacturer's recommendations shall govern.

6. If there are no local codes having jurisdiction, the current issue of the NEC shall be followed.

D. Permits, Fees, Taxes, Inspections:

1. Procure all applicable permits and licenses.

2. Abide by all laws, regulations, ordinances, and other rules of the State or Political Subdivision where the work is done, or as required by any duly constituted public authority.

3. Pay all charges for permits or licenses.

4. Pay all fees and taxes imposed by State, Municipal, and other regulatory bodies.

5. Pay all charges arising out of required inspections by an authorized body.

6. Pay all charges arising out of required contract document reviews associated with the project and as initiated by the Owner or authorized agency/consultant.

7. Where applicable, all fixtures, equipment and materials shall be listed by Underwriter's Laboratories, Inc. or a nationally recognized testing organization.

8. Pay all telephone company charges related to the service or change in service.

E. Utility Company Requirements:

1. Secure from the private or public utility company all applicable requirements.

2. Comply with all utility company requirements.

3. The Owner shall make application for and pay for new electrical service equipment and installation. The Contractor shall coordinate schedule and requirements with the Owner and Utility Company.

4. Furnish the meter socket and C.T. cabinet. Verify approved manufacturers and equipment with the Utility Company.

5. The Owner shall apply and pay for any changes for removal of existing electrical service by the utility company. The Contractor shall verify approved manufacturers and equipment with the Utility Company.

F. Examination of Drawings:

1. The drawings for the electrical work are completely diagrammatic, intended to convey the scope of the work and to indicate the general arrangements and locations of equipment, outlets, etc., and the approximate sizes of equipment.

2. Contractor shall determine the exact locations of equipment and rough-ins, and the exact routing of raceways so as to best fit the layout of the job. Conduit entry points for electrical equipment including, but not limited to, panelboards, switchboards, switchgear and unit substations, shall be determined by the Contractor unless noted in the contract documents.

3. Scaling of the drawings will not be sufficient or accurate for determining these locations.

4. Where job conditions require reasonable changes in arrangements and locations, such changes shall be made by the Contractor at no additional cost to the Owner.

5. Because of the scale of the drawings, certain basic items, such as junction boxes, pull boxes, conduit fittings, etc., may not be shown, but where required by other sections of the specifications or required for proper installation of the work, such items shall be furnished and installed.

6. If an item is either shown on the drawings or called for in the specifications, it shall be included in this contract.

7. The Contractor shall determine quantities and quality of material and equipment required from the documents. Where discrepancies arise between drawings, schedules and/or specifications, the greater and better quality number shall govern.

8. Where used in electrical documents the word “furnish” shall mean supply for use, the word “install” shall mean connect up complete and ready for operation, and the word “provide” shall mean to supply for use and connect up complete and ready for operation.

9. Any item listed as furnished shall also be installed unless otherwise noted.

10. Any item listed as installed shall also be furnished unless otherwise noted.

G. Electronic Media/Files:

1. Construction drawings for this project have been prepared utilizing Revit.

2. Contractors and Subcontractors may request electronic media files of the contract drawings and/or copies of the specifications. Specifications will be provided in PDF format.

3. Upon request for electronic media, the Contractor shall complete and return a signed “Electronic File Transmittal” form provided by IMEG.

4. If the information requested includes floor plans prepared by others, the Contractor will be responsible for obtaining approval from the appropriate Design Professional for use of that part of the document.

5. The electronic contract documents can be used for preparation of shop drawings and as-built drawings only. The information may not be used in whole or in part for any other project.

6. The drawings prepared by IMEG for bidding purposes may not be used directly for ductwork layout drawings or coordination drawings.

7. The use of these CAD documents by the Contractor does not relieve them from their responsibility for coordination of work with other trades and verification of space available for the installation.

8. The information is provided to expedite the project and assist the Contractor with no guarantee by IMEG as to the accuracy or correctness of the information provided. IMEG accepts no responsibility or liability for the Contractor’s use of these documents.

H. Field Measurements:

1. Verify all pertinent dimensions at the job site before ordering any conduit, conductors, wireways, bus duct, fittings, etc.

1.8 SUBMITTALS

A. Submittals shall be required for the following items, and for additional items where required elsewhere in the specifications or on the drawings.

1. Submittals list:

Referenced Specification Section	Submittal Item
26 05 26	Grounding and Bonding
26 05 35	Surface Raceways
26 05 73	Power System Study
26 09 33	Lighting Control System
26 20 00	Service Entrance
26 24 16	Panelboards
26 24 19	Motor Control
26 27 26	Wiring Devices
26 28 13	Fuses
26 28 16	Disconnect Switches
26 28 21	Contactors
28 31 00	Fire Alarm and Detection Systems

B. General Submittal Procedures: In addition to the provisions of Division 1, the following are required:

1. Transmittal: Each transmittal shall include the following:

a. Date
b. Project title and number
c. Contractor's name and address
d. Division of work (e.g., electrical, plumbing, heating, ventilating, etc.)
e. Description of items submitted and relevant specification number
f. Notations of deviations from the contract documents
g. Other pertinent data

2. Submittal Cover Sheet: Each submittal shall include a cover sheet containing:

a. Date
b. Project title and number
c. Architect/Engineer
d. Contractor and subcontractors' names and addresses
e. Supplier and manufacturer's names and addresses
f. Division of work (e.g., electrical, plumbing, heating, ventilating, etc.)
g. Description of item submitted (using project nomenclature) and relevant specification number
h. Notations of deviations from the contract documents
i. Other pertinent data
j. Provide space for Contractor's review stamps

3. Composition:

a. Submittals shall be submitted using specification sections and the project nomenclature for each item.

b. Individual submittal packages shall be prepared for items in each specification section. All items within a single specification section shall be packaged together where possible. An individual submittal may contain items from multiple specifications sections if the items are intimately linked (e.g., pumps and motors).

c. All sets shall contain an index of the items enclosed with a general topic description on the cover.

4. Content: Submittals shall include all fabrication, erection, layout, and setting drawings; manufacturers' standard drawings; schedules; descriptive literature, catalogs and brochures; performance and test data; wiring and control diagrams; dimensions; shipping and operating weights; shipping splits; service clearances; and all other drawings and descriptive data of materials of construction as may be required to show that the materials, equipment or systems and the location thereof conform to the requirements of the contract documents.

5. Contractor's Approval Stamp:

a. The Contractor shall thoroughly review and approve all shop drawings before submitting them to the Architect/Engineer. The Contractor shall stamp, date and sign each submittal certifying it has been reviewed.

b. Unstamped submittals will be rejected.

c. The Contractor's review shall include, but not be limited to, verification of the following:

1) Only approved manufacturers are used.
2) Addenda items have been incorporated.
3) Catalog numbers and options match those specified.
4) Performance data matches that specified.
5) Electrical characteristics and loads match those specified.
6) Equipment connection locations, sizes, capacities, etc. have been coordinated with other affected trades.
7) Dimensions and service clearances are suitable for the intended location.
8) Equipment dimensions are coordinated with support steel, housekeeping pads, openings, etc.
9) Constructability issues are resolved (e.g., weights and dimensions are suitable for getting the item into the building and into place, sinks fit into countertops, etc.).

d. The Contractor shall review, stamp and approve all subcontractors' submittals as described above.

e. **The Contractor's approval stamp is required on all submittals. Approval will indicate the Contractor's review of all material and a complete understanding of exactly what is to be furnished. Contractor shall clearly mark all deviations from the contract documents on all submittals. If deviations are not marked by the Contractor, then the item shall be required to meet all drawing and specification requirements.**

6. Submittal Identification and Markings:

a. The Contractor shall clearly mark each item with the same nomenclature applied on the drawings or in the specifications.

b. The Contractor shall clearly indicate the size, finish, material, etc.

c. Where more than one model is shown on a manufacturer's sheet, the Contractor shall clearly indicate exactly which item and which data is intended.

d. All marks and identifications on the submittals shall be unambiguous.

7. Schedule submittals to expedite the project. Coordinate submission of related items.

8. Identify variations from the contract documents and product or system limitations that may be detrimental to the successful performance of the completed work.

9. Reproduction of contract documents alone is not acceptable for submittals.

10. Incomplete submittals will be rejected without review. Partial submittals will only be reviewed with prior approval from the Architect/Engineer.

11. Submittals not required by the contract documents may be returned without review.

12. The Architect/Engineer's responsibility shall be to review one set of shop drawing submittals for each product. If the first submittal is incomplete or does not comply with the drawings and/or specifications, the Contractor shall be responsible to bear the cost for the Architect/Engineer to recheck and handle the additional shop drawing submittals.

13. Submittals shall be reviewed and approved by the Architect/Engineer **before** releasing any equipment for manufacture or shipment.

14. Contractor's responsibility for errors, omissions or deviation from the contract documents in submittals is not relieved by the Architect/Engineer's approval.

C. Electronic Submittal Procedures:

1. Distribution: Email submittals as attachments to all parties designated by the Architect/Engineer, unless a web-based submittal program is used.

2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.

3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.

4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

   a. Submittal file name: 26 XX XX.description.YYYYMMDD
   b. Transmittal file name: 26 XX XX.description.YYYYMMDD

5. File Size: Electronic file size shall be limited to a maximum of 4MB. Larger files shall be transmitted via a pre-approved method.

1.9 SCHEDULE OF VALUES

A. The requirements herein are in addition to the provisions of Division 1.

B. Format:

1. Use AIA Document Continuation Sheets G703 or another similar form approved by the Owner and Architect/Engineer.
2. Submit in Excel format.
3. Support values given with substantiating data.

C. Preparation:

1. Itemize work required by each specification section and list all providers. All work provided by subcontractors and major suppliers shall be listed on the Schedule of Values. List each subcontractor and supplier by company name.

2. Break down all costs into:

a. Material: Delivered cost of product with taxes paid.
b. Labor: Labor cost, excluding overhead and profit.

D. Update Schedule of Values when:

1. Indicated by Architect/Engineer.
2. Change of subcontractor or supplier occurs.
3. Change of product or equipment occurs.

1.10 CHANGE ORDERS

A. A detailed material and labor takeoff shall be prepared for each change order, along with labor rates and markup percentages. Change orders with inadequate breakdown will be rejected.

B. Change order work shall not proceed until authorized.

1.11 PRODUCT DELIVERY, STORAGE, HANDLING AND MAINTENANCE

A. Exercise care in transporting and handling to avoid damage to materials. Store materials on the site to prevent damage.

B. Keep all materials clean, dry and free from damaging environments.

C. Coordinate the installation of heavy and large equipment with the General Contractor and/or Owner. If the Electrical Contractor does not have prior documented experience in rigging and lifting similar equipment, he/she shall contract with a qualified lifting and rigging service that has similar documented experience. Follow all equipment lifting and support guidelines for handling and moving.

D. Contractor is responsible for moving equipment into the building and/or site. Contractor shall review site prior to bid for path locations and any required building modifications to allow movement of equipment. Contractor shall coordinate his/her work with other trades.

1.12 NETWORK / INTERNET CONNECTED EQUIPMENT

A. These specifications may require certain equipment or systems to have network, Internet and/or remote access capability ("Network Capability"). Any requirement for Network Capability shall be interpreted only as a functional capability and is not to be construed as authority to connect or enable any Network Capability. Network Capability may only be connected or enabled with the express written consent of the Owner.

1.13 WARRANTY

A. Refer to Division 01 specification for requirements.

1.14 INSURANCE

A. This Contractor shall maintain insurance coverage as set forth in Division 1 of these specifications.

1.15 MATERIAL SUBSTITUTION

A. Refer to Division 01 specification for requirements.

1.16 LEED REQUIREMENTS

A. This project is pursuing a LEED certification in accordance with USGBC LEED Rating System for New Construction v3. The Contractor shall provide all services and documentation necessary to achieve this rating. Refer to architectural specifications.

1.17 PROJECT COMMISSIONING

A. The Contractor shall work with the Commissioning Agent (CxA) as described in Section and provide all services necessary for compliance with LEED Prerequisite EAp1, Fundamental Commissioning, and EAc3 Enhanced Commissioning.

PART 2 - PRODUCTS

2.1 GENERAL

A. All items of material having a similar function (e.g., safety switches, panelboards, switchboards, contactors, motor starters, dry type transformers) shall be of the same manufacturer unless specifically stated otherwise on drawings or elsewhere in specifications.

PART 3 - EXECUTION

3.1 JOBSITE SAFETY

A. Neither the professional activities of the Architect/Engineer, nor the presence of the Architect/Engineer or his or her employees and subconsultants at a construction site, shall relieve the Contractor and any other entity of their obligations, duties and responsibilities including, but not limited to, construction means, methods, sequence, techniques or procedures necessary for performing, superintending or coordinating all portions of the work of construction in accordance with the contract documents and any health or safety precautions required by any regulatory agencies. The Architect/Engineer and his or her personnel have no authority to exercise any control over any construction contractor or other entity or their employees in connection with their work or any health or safety precautions. The Contractor is solely responsible for jobsite safety. The Architect/Engineer and the Architect/Engineer's consultants shall be indemnified and shall be made additional insureds under the Contractor's general liability insurance policy.

3.2 EXCAVATION, FILL, BACKFILL, COMPACTION

A. General:

1. Prior to the commencement of any excavation or digging, the Contractor shall verify all underground utilities with the regional utility locator. Provide prior notice to the locator before excavations. Contact information for most regional utility locaters can be found by calling 811.

2. The Contractor shall do all excavating, filling, backfilling, compacting, and restoration in connection with his work.

B. Excavation:

1. Make all excavations to accurate, solid, undisturbed earth, and to proper dimensions.

2. If excavations are carried in error below indicated levels, concrete of same strength as specified for the foundations or thoroughly compacted sand-gravel fill, as determined by the Architect/Engineer shall be placed in such excess excavations under the foundation. Place thoroughly compacted, clean, stable fill in excess excavations under slabs on grade, at the Contractor's expense.

3. Trim bottom and sides of excavations to grades required for foundations.

4. Protect excavations against frost and freezing.

5. Take care in excavating not to damage surrounding structures, equipment or buried pipe. Do not undermine footing or foundation.

6. Perform all trenching in a manner to prevent cave-ins and risk to workmen.

7. Where original surface is pavement or concrete, the surface shall be saw cut to provide clean edges and assist in the surface restoration.

8. If satisfactory bearing soil is not found at the indicated levels, immediately notify the Architect/Engineer or their representative, and do no further work until the Architect/Engineer or their representative gives further instructions.

9. Excavation shall be performed in all ground conditions, including rock, if encountered. Bidders shall visit the premises and determine the soil conditions by actual observations, borings, or other means. The cost of all such inspections, borings, etc., shall be borne by the bidder.

10. If a trench is excavated in rock, a compacted bed with a depth of 3" (minimum) of sand and gravel shall be used to support the conduit unless masonry cradles or encasements are used.

11. Mechanical excavation of the trench to line and grade of the conduit or to the bottom level of masonry cradles or encasements is permitted, unless otherwise indicated on the electrical drawings.

12. Mechanical excavation of the trench to line and grade where direct burial cables are to be installed is permitted provided the excavation is made to a depth to permit installation of the cable on a fine sand bed at least 3 inches deep.

C. Dewatering:

1. Furnish, install, operate and remove all dewatering pumps and pipes needed to keep trenches and pits free of water.

D. Underground Obstructions:

1. Known underground piping, conduit, feeders, foundations, and other obstructions in the vicinity of construction are shown on the drawings. Review all Bid Documents for all trades on the project to determine obstructions indicated. Take great care in making installations near underground obstructions.

2. If objects not shown on the drawings are encountered, remove, relocate, or perform extra work as directed by the Architect/Engineer.

E. Fill and Backfilling:

1. No rubbish or waste material is permitted for fill or backfill.

2. Furnish all necessary sand for backfilling.

3. Dispose of the excess excavated earth as directed.

4. Backfill materials shall be suitable for required compaction, clean and free of perishable materials, frozen earth, debris, earth with a high void content, and stones greater than 4 inches in diameter. Water is not permitted to rise in unbackfilled trenches.

5. Backfill all trenches and excavations immediately after installing of conduit, or removing forms, unless other protection is directed.

6. Around piers and isolated foundations and structures, backfill and fill shall be placed and consolidated simultaneously on all sides to prevent wedge action and displacement. Spread fill and backfill materials in 6” uniform horizontal layers with each layer compacted separately to required density.

7. For conduits that are not concrete encased, lay all conduits on a compacted bed of sand at least 3" deep. Backfill around conduits with sand, in 6" layers and compact each layer.

8. Conduits that are concrete encased or in a ductbank, conduit spacers, and cradles shall be installed on a bed of compacted CA-6 gravel. Refer to conduit section for backfilling and ductbank requirements.

9. Backfill with sand up to grade for all conduits under slabs or paved areas. All other conduits shall have sand backfill to 6" above the top of the conduit.

10. Place all backfill above the sand in uniform layers not exceeding 6” deep. Place then carefully and uniformly tamp each layer to eliminate lateral or vertical displacement.

11. Where the fill and backfill will ultimately be under a building, floor or paving, each layer of fill shall be compacted to 95% of the maximum density as determined by AASHTO Designation T-99 or ASTM Designation D-698. Moisture content of soil at time of compaction shall not exceed plus or minus 2% of optimum moisture content as determined by AASHTO T-99 or ASTM D-698 test.

12. After backfilling of trenches, no superficial loads shall be placed on the exposed surface of the backfill until a period of 48 hours has elapsed.

F. Surface Restoration:

1. Where trenches are cut through graded, planted or landscaped areas, the areas shall be restored to the original condition. Replace all planting and landscaping features removed or damaged to its original condition. At least 6” of topsoil shall be applied where disturbed areas are to be seeded or sodded. All lawn areas shall be sodded unless seeding is called out in the drawings or specifications.

2. Concrete or asphalt type pavement, seal coat, rock, gravel or earth surfaces removed or damaged shall be replaced with comparable materials and restored to original condition. Broken edges shall be saw cut and repaired as directed by Architect/Engineer.

3.3 ARCHITECT/ENGINEER OBSERVATION OF WORK

A. The contractor shall provide seven (7) calendar days’ notice to the Architect/Engineer prior to:

1. Placing fill over underground and underslab utilities.

2. Covering exterior walls, interior partitions and chases.

3. Installing hard or suspended ceilings and soffits.

B. The Architect/Engineer will review the installation and provide a written report noting deficiencies requiring correction. The contractor’s schedule shall account for these reviews and show them as line items in the approved schedule.

C. Above-Ceiling Final Observation:

1. All work above the ceilings must be complete prior to the Architect/Engineer’s review. This includes, but is not limited to:

a. All junction boxes are closed and identified in accordance with Section 26 05 53 Electrical Identification.

b. Light fixtures, including ceiling-mounted exit and emergency lights, are installed and operational.

c. Light fixture whips are suspended above the ceiling.

d. Conduit identification is installed in accordance with Section 26 05 53 Electrical Identification.

e. Light fixtures are suspended independently of the ceiling system when required by these contract documents.

f. All wall penetrations have been sealed.

2. In order to prevent the Above-Ceiling Final Observation from occurring too early, the Contractor shall review the status of the work and certify, in writing, that the work is ready for the Above-Ceiling Final Observation.

3. It is understood that if the Architect/Engineer finds the ceilings have been installed prior to this review and prior to seven days elapsing, the Architect/Engineer may not recommend further payments to the contractor until such time as full access has been provided.

3.4 PROJECT CLOSEOUT

A. The following paragraphs supplement the requirements of Division 1.

B. Final Jobsite Observation:

1. In order to prevent the Final Jobsite Observation from occurring too early, the Contractor shall review the completion status of the project and certify that the job is ready for the final jobsite observation.

2. Attached to the end of this section is a typical list of items that represent the degree of job completeness expected prior to requesting a review. The Contractor shall sign the attached certification and return it to the Architect/Engineer so that the final observation can be scheduled.

3. It is understood that if the Architect/Engineer finds the job not ready for the final observation and additional trips and observations are required to bring the project to completion, the cost of the additional time and expenses incurred by the Architect/Engineer will be deducted from the Contractor’s final payment.

4. Contractor shall notify Architect/Engineer 48 hours prior to installation of ceilings or lay-in ceiling tiles.

C. The following must be submitted before Architect/Engineer recommends final payment:

1. Operation and maintenance manuals with copies of approved shop drawings.

2. Record documents including reproducible drawings and specifications.

3. A report documenting the instructions given to the Owner's representatives complete with the number of hours spent in the instruction. The report shall bear the signature of an authorized agent of this Contractor and shall be signed by the Owner's representatives.

4. Provide spare parts, maintenance, and extra materials in quantities specified in individual specification sections. Deliver to project site and place in location as directed and submit receipt to Architect/Engineer.

5. Inspection and testing report by the fire alarm system manufacturer.

6. Start-up reports on all equipment requiring a factory installation or start-up.

3.5 OPERATION AND MAINTENANCE MANUALS

A. Refer to Division 01 specification for requirements.

3.6 INSTRUCTING THE OWNER'S REPRESENTATIVE

A. Adequately instruct the Owner's designated representatives in the maintenance, care, and operation of the complete systems installed under this contract as set forth in Division 1 specifications.

B. Provide verbal and written instructions to the Owner's representatives by FACTORY PERSONNEL in the care, maintenance, and operation of the equipment and systems.

C. The Owner has the option to make a video recording of all instructions. Coordinate schedule of instructions to facilitate this recording.

D. The instructions shall include:

1. Maintenance of equipment.
2. Start-up procedures for all major equipment.
3. Description of emergency system operation.

E. Notify the Architect/Engineer of the time and place for the verbal instructions to the Owner's representative so his representative can be present if desired.

F. Minimum hours of instruction time for each item and/or system shall be as indicated in each individual specification section.

G. Operating Instructions:

1. Contractor is responsible for all instructions to the Owner’s representatives for the electrical and specialized systems.

2. If the Contractor does not have staff that can adequately provide the required instructions, he shall include in his bid an adequate amount to reimburse the Owner for the Architect/Engineer to perform these services.

3.7 RECORD DOCUMENTS

A. The following paragraphs supplement the requirements of Division 1.

B. Maintain at the job site a separate and complete set of electrical drawings and specifications with all changes made to the systems clearly and permanently marked in complete detail.

C. Mark drawings and specifications to indicate approved substitutions; Change Orders, and actual equipment and materials used. All Change Orders, RFI responses, Clarifications and other supplemental instructions shall be marked on the documents. Record documents that merely reference the existence of the above items are not acceptable. Should this Contractor fail to complete Record Documents as required by this contract, this Contractor shall reimburse Architect/Engineer for all costs to develop record documents that comply with this requirement. Reimbursement shall be made at the Architect/Engineer’s hourly rates in effect at the time of work.

D. Record changes daily and keep the marked drawings available for the Architect/Engineer's examination at any normal work time.

E. Upon completing the job, and before final payment is made, give the marked-up drawings to the Architect/Engineer.

3.8 PAINTING

A. Paint all equipment that is marred or damaged prior to the Owner's acceptance. Paint and color shall match original equipment paint and shall be obtained from the equipment supplier if available. All equipment shall have a finished coat of paint applied unless specifically allowed to be provided with a prime coat only.

B. Equipment in finished areas that will be painted to match the room decor will be painted by others. Should this Contractor install equipment in a finished area after the area has been painted, he shall have the equipment and all its supports, hangers, etc., painted to match the room decor. Painting shall be performed as described in project specifications.

C. Equipment cabinets, casings, covers, metal jackets, etc., located in equipment rooms or concealed spaces, shall be furnished in standard finish, free from scratches, abrasions, chippings, etc.

D. Equipment in occupied spaces, or if standard to the unit, shall have a baked primer with baked enamel finish coat free from scratches, abrasions, chipping, etc. If color option is specified or is standard to the unit, verify with the Architect his color preference before ordering.

E. Paint all equipment in unfinished areas such as boiler room, mechanical spaces, and storage rooms. Equipment furnished with a suitable factory finish need not be painted; provided the factory applied finish is not marred or spattered. If so, equipment shall be refinished with the same paint as was factory applied.

F. All electrical conduit and equipment, fittings, hangers, structural supports, etc., in unfinished areas, such as equipment and storage room area, shall be painted two (2) coats of oil paint of colors selected by the Architect.

G. Do NOT paint electric conduits in crawl spaces, tunnels, or spaces above suspended ceilings except that where conduit is in a damp location give exposed threads at joints two coats of sealer after joint is made up.

H. After surfaces have been thoroughly cleaned and are free of oil, dirt or other foreign matter, paint all raceway and equipment with the following:

1. Bare Metal Surfaces - Apply one coat of metal primer suitable for the metal being painted. Finish with two coats of Alkyd base enamel paint.

2. Plastic Surfaces - Paint plastic surfaces with two coats of semi-gloss acrylic latex paint.

I. In accordance with LEED EQc4.2: Low-Emitting Materials - Paints and Coatings, all paints and coatings used on the interior of the building must comply with the following criteria:

1. Architectural paints and coatings applied to interior walls and ceilings must not exceed the volatile organic compound (VOC) content limits established in Green Seal Standard GS-11, Paints, 1st Edition, May 20, 1993.

2. Anti-corrosive and anti-rust paints applied to interior ferrous metal substrates must not exceed the VOC content limit of 250 g/L (2 lb./gal) established in Green Seal Standard GC-03, Anti-Corrosive Paints, 2nd Edition, January 7, 1997.

3.9 ADJUST AND CLEAN

A. Thoroughly clean all equipment and systems prior to the Owner's final acceptance of the project.

B. Clean all foreign paint, grease, oil, dirt, labels, stickers, etc. from all equipment.

C. Remove all rubbish, debris, etc., accumulated during construction from the premises.

3.10 SPECIAL REQUIREMENTS

A. Coordinate the installation of all equipment, controls, devices, etc., with other trades to maintain clear access area for servicing.

B. Install all equipment to maximize access to parts needing service or maintenance. Review the final location, placement, and orientation of equipment with the Owner's representative prior to setting equipment.

C. Installation of equipment or devices without regard to coordination of access requirements and confirmation with the Owner's representative will result in removal and reinstallation of the equipment at the Contractor's expense.

D. In accordance with LEED EQc4.1, Low-Emitting Materials - Adhesives and Sealants, all adhesives and sealants used on the interior of the building must comply with the following requirements:

1. Adhesives, sealants and sealant primers must comply with South Coast Air Quality Management District (SCAQMD) Rule #1168.

2. Aerosol adhesives must comply with Green Seal Standard for Commercial Adhesives GS-36 requirements in effect on October 19, 2000.

3.11 INDOOR AIR QUALITY (IAQ) MAINTENANCE FOR OCCUPIED FACILITIES UNDER CONSTRUCTION

A. Within the limits of Construction:

1. The Electrical Contractor shall coordinate all work with the contractor responsible for IAQ.

2. The means, methods and materials used by the Electrical Contractor shall be coordinated with the contractor responsible for IAQ and shall comply with the IAQ requirements set forth in Division 1 and Division 21/22/23 of these specifications.

B. Outside the limits of Construction:

1. IAQ shall be the responsibility of the electrical contractor for work that is required outside the limits of construction.

2. The Electrical Contractor is responsible for the IAQ set forth in Division 1 and Division 21/22/23 of these specifications.

3. The Electrical Contractor shall review and coordinate all IAQ plans and procedures with the owner's IAQ representative.

3.12 SYSTEM STARTING AND ADJUSTING

A. The electrical systems shall be complete and operating. System startup, testing, adjusting, and balancing to obtain satisfactory system performance is the responsibility of the Contractor. This includes all calibration and adjustment of electrical controls, balancing of loads, troubleshooting and verification of software, and final adjustments that may be needed.

B. Complete all manufacturer-recommended startup procedures and checklists to verify proper equipment operation and does not pose a danger to personnel or property.

C. All operating conditions and control sequences shall be tested during the start-up period. Testing all interlocks, safety shut-downs, controls, and alarms.

D. The Contractor, subcontractors, and equipment suppliers shall have skilled technicians to ensure that all systems perform properly. If the Architect/Engineer is requested to visit the job site for trouble shooting, assisting in start-up, obtaining satisfactory equipment operation, resolving installation and/or workmanship

problems, equipment substitution issues or unsatisfactory system performance, including call backs during the warranty period, through no fault of the design; the Contractor shall reimburse the Owner on a time and materials basis for services rendered at the Architect/Engineer's standard hourly rates in effect when the services are requested. The Contractor shall pay the Owner for services required that are product, installation or workmanship related. Payment is due within 30 days after services are rendered.

3.13 FIELD QUALITY CONTROL

A. General:

1. Conduct all tests required during and after construction. Submit test results in NETA format, or equivalent form, that shows the test equipment used, calibration date, tester's name, ambient test conditions, humidity, conductor length, and results corrected to 40°C.

2. Supply necessary instruments, meters, etc., for the tests. Supply competent technicians with training in the proper testing techniques.

3. All cables and wires shall be tested for shorts and grounds following installation and connection to devices. Replace shorted or grounded wires and cables.

4. Any wiring device, electrical apparatus or lighting fixture, if grounded or shorted on any integral "live" part, shall have all defective parts or materials replaced.

5. Test cable insulation of service and panel feeder conductors for proper insulation values. Tests shall include the cable, all splices, and all terminations. Each conductor shall be tested and shall test free of short circuits and grounds and have an insulation value not less than NEC Standards. Take readings between conductors, and between conductors and ground.

6. If the results obtained in the tests are not satisfactory make adjustments, replacements, and changes as needed. Then repeat the tests, and make additional tests, as the Architect/Engineer or authority having jurisdiction deems necessary.

B. Ground Resistance:

1. Conduct service ground resistance tests using an approved manufactured ground resistance meter. Submit to the Architect/Engineer a proposed test procedure including type of equipment to be used. (The conventional ohmmeter is not an acceptable device.)

2. Make ground resistance measurements during normal dry weather and not less than 48 hours after a rain.

3. If the ground resistance value obtained is more than the value set forth in Section 26 05 26, the following shall be done to obtain the value given:

   a. Verify that all connections in the service ground system are secure.

   b. Increase the depth to which ground rods are driven by adding section lengths to the rods and retest. If the resistance is still excessive increase the depth by adding an additional rod section and retest.

   c. If the resistance is still excessive, furnish and install additional ground rods, spaced not less than 20 feet from other ground rods unless otherwise noted on plans, and connect into the ground electrode system. Retest.

   d. Review results with the Architect/Engineer.

4. Before final payment is made to the Contractor submit a written report to the Architect/Engineer including the following:

a. Date of test.

b. Number of hours since the last rain.

c. Soil condition at the time of the test in the ground electrode location. That is: dry, wet, moist, sand, clay, etc.

d. Diagram of the test set-up showing distances between test equipment, ground electrode, auxiliary electrodes, etc.

e. Make, model, and calibration date of test equipment.

f. Tabulation of measurements taken and calculations made.

C. Other Equipment:

1. Give other equipment furnished and installed by the Contractor all standard tests normally made to assure that the equipment is electrically sound, all connections properly made, phase rotation correct, fuses and thermal elements suitable for protection against overloads, voltage complies with equipment nameplate rating, and full load amperes are within equipment rating.

D. If any test results are not satisfactory, make adjustments, replacements and changes as needed and repeat the tests and make additional tests as the Architect/Engineer or authority having jurisdiction deem necessary.

E. Upon completion of the project, the Contractor shall provide amperage readings for all panelboards and switchboards and turn the results over to the Owner for “benchmark” amperages.

3.14 CONSTRUCTION WASTE MANAGEMENT

A. This Contractor shall comply with all construction and demolition waste disposal and recycling requirements outlined in LEED MRc2: Construction Waste Management (follow latest edition at the time of bidding or as referenced in these specifications).

1. This Contractor shall coordinate with the General Contractor to develop and implement a construction waste management plan that, at a minimum, identifies the materials to be diverted from disposal and whether the materials will be sorted on-site or co-mingled.

2. The Contractor shall track waste disposal and recycling efforts throughout the construction process for all materials associated with this Contractor’s scope of work. The Contractor shall provide this information to the General Contractor so that it can be incorporated with similar information from all other contractors for the project.

a. Calculations for waste and recycled material can be done by weight or volume, but they must be consistent throughout the project. The Contractor shall coordinate with the General Contractor to establish the preferred calculation method and report the results accordingly.

b. Excavated soil and land-clearing debris do not count towards the waste disposal or recycled material.

END OF SECTION

READINESS CERTIFICATION PRIOR TO FINAL JOBSITE OBSERVATION

In order to prevent the final job observation from occurring too early, we require that the Contractor review the completion status of the project and, by copy of this document, certify that the job is indeed ready for the final job observation. The following is a typical list of items that represent the degree of job completeness expected prior to your requesting a final job observation.

1. Penetrations of fire-rated construction fire sealed in accordance with specifications.
2. Electrical panels have typed circuit identification.
3. Smoke and fire/smoke dampers are wired and have been tested.
4. Per Section 26 05 00, cable insulation test results have been submitted.
5. Per Section 26 05 00, medium voltage testing report has been submitted.
6. Per Section 26 05 00, ground resistance test results have been submitted.
7. Operation and Maintenance manuals have been submitted as per Section 26 05 00.
8. Bound copies of approved shop drawings have been submitted as per Section 26 05 00.
9. Report of instruction of Owner's representative has been submitted as per Section 26 05 00.
10. Fire alarm inspection and testing report has been submitted as per Sections 26 05 00 and 28 31 00.
11. Start-up reports from factory representative have been submitted as per Section 26 05 00.

Accepted by:

Prime Contractor _____

By _____ Date _____

Upon Contractor certification that the project is complete and ready for a final job observation, we require the Contractor to sign this agreement and return it to the Architect/Engineer so that the final observation can be scheduled.

It is understood that if the Architect/Engineer finds the job not ready for the final observation and that additional trips and observations are required to bring the project to completion, the costs incurred by the Architect/Engineers for additional time and expenses will be deducted from the Contractor's contract retainage prior to final payment at the completion of the job.

* * * * * *

SECTION 26 05 03
THROUGH PENETRATION FIRESTOPPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Through-Penetration Firestopping.

1.2 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing products specified in this Section.

B. Installer: Individuals performing work shall be certified by the manufacturer of the system selected for installation.

1.3 REFERENCES

A. UL 723 - Surface Burning Characteristics of Building Materials
B. ANSI/UL 1479 - Fire Tests of Through Penetration Firestops
C. UL Fire Resistance Directory Through Penetration Firestop Systems (XHEZ)
D. Intertek / Warnock Hersey - Directory of Listed Products
E. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials
F. ASTM E814 - Standard Test Method for Fire Tests of Through-Penetration Firestops
G. The Building Officials and Code Administrators National Building Code
H. Uniform Building Code
I. Wisconsin Administrative Code
J. International Building Code
K. NFPA 5000 – Building Construction Safety Code

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store, protect and handle products on site. Accept material on site in factory containers and packing. Inspect for damage. Protect from deterioration or damage due to moisture, temperature changes, contaminants, or other causes. Follow manufacturer's instructions for storage.

B. Install material prior to expiration of product shelf life.

1.5 PERFORMANCE REQUIREMENTS

A. General: For penetrations through the following fire-resistance-rated constructions, including both empty openings and openings containing penetrating items, provide through-penetration firestop systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated.

1. Fire-resistance-rated walls including fire partitions, fire barriers, and smoke barriers.
2. Fire-resistance-rated horizontal assemblies including floors, floor/ceiling assemblies, and ceiling membranes of roof/ceiling assemblies.

B. Rated Systems: Provide through-penetration firestop systems with the following ratings determined per UL 1479:

1. F-Rated Systems: Provide through-penetration firestop systems with F-ratings indicated, but not less than that equaling or exceeding fire-resistance rating of constructions penetrated.
2. T-Rated Systems: For the following conditions, provide through-penetration firestop systems with T-ratings indicated, as well as F-ratings**:**

a. Floor penetrations located outside wall cavities.
b. Floor penetrations located outside fire-resistance-rated shaft enclosures.

3. L-Rated Systems: Provide through-penetration firestop systems with L-ratings of not more than 5.0 cfm/sq.ft. (0.0254 cu. m/s x sq. m) at both ambient temperature and 400°F (204°C) for smoke barriers.

C. For through-penetration firestop systems exposed to light, traffic, moisture, or physical damage, provide products that, after curing, do not deteriorate when exposed to these conditions both during and after construction.

D. For through-penetration firestop systems exposed to view, provide products with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.

E. For through-penetration firestop systems in air plenums, provide products with flame-spread and smoke-developed indexes of less than 25 and 50, respectively, as determined per ASTM E 84.

F. In accordance with LEED EQc4.1, Low-Emitting Materials - Adhesives and Sealants, all adhesives and sealants used on the interior of the building must comply with the following requirements:

1. Adhesives, sealants and sealant primers must comply with South Coast Air Quality Management District (SCAQMD) Rule #1168.

2. Aerosol adhesives must comply with Green Seal Standard for Commercial Adhesives GS-36 requirements in effect on October 19, 2000.

1.6 MEETINGS

A. Pre-installation meeting: A pre-installation meeting shall be scheduled and shall include the Construction Manager, General Contractor, all Subcontractors associated with the installation of systems penetrating fire barriers, Firestopping Manufacturer's Representative, and the Owner.

1. Review foreseeable methods related to firestopping work.

2. Tour representative areas where firestopping is to be installed; inspect and discuss each type of condition and each type of substrate that will be encountered, and preparation to be performed by other trades.

1.7 WARRANTY

A. Provide one year warranty on parts and labor.

B. Warranty shall cover repair or replacement of firestop systems which fail in joint adhesion, cohesion, abrasion resistance, weather resistance, extrusion resistance, migration resistance, stain resistance, general durability, or appear to deteriorate in any manner not clearly specified by the manufacturer as an inherent quality of the material.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide one of the through-penetration firestop systems indicated for each application that are produced by one of the following manufacturers. All firestopping systems installed shall be provided by a single manufacturer.

1. 3M; Fire Protection Produces Division.
2. Hilti, Inc.

3. RectorSeal Corporation, Metacaulk.
4. Tremco; Sealant/Weatherproofing Division.
5. Johns-Manville.
6. Specified Technologies Inc. (S.T.I.)
7. Spec Seal Firestop Products
8. AD Firebarrier Protection Systems
9. Wiremold/legrand: FlameStopper

2.2 THROUGH PENETRATION FIRESTOP SYSTEMS

A. Provide materials and systems classified by or listed by Intertek / Warnock Hersey to provide firestopping equal to time rating of construction being penetrated.

B. All firestopping materials shall be free of asbestos, lead, PCB's, and other materials that would require hazardous waste removal.

C. Firestopping shall be flexible to allow for normal penetrating item movement due to expansion and contraction.

D. Provide firestopping systems capable of supporting floor loads where systems are exposed to possible floor loading or traffic.

E. Provide firestopping systems allowing continuous insulation for all insulated pipes.

F. Provide firestopping systems classified by UL or listed by Intertek / Warnock Hersey for penetrations through all fire rated construction. Firestopping systems shall be selected from the UL or listed by Intertek / Warnock Hersey Fire Resistance Directory Category XHEZ based on substrate construction and penetrating item size and material and shall fall within the range of numbers listed:

1. Combustible Framed Floors and Chase Walls - 1 or 2 Hour Rated
   F Rating = Floor/Wall Rating
   T Rating = Floor/Wall Rating
   L Rating = Penetrations in Smoke Barriers

Penetrating Item	UL System No.
No Penetrating Item	FC 0000-0999*
Metallic Pipe or Conduit	FC 1000-1999
Non-Metallic Pipe or Conduit	FC 2000-2999
Electrical Cables	FC 3000-3999
Cable Trays	FC 4000-4999
Insulated Pipes	FC 5000-5999
Bus Duct and Misc. Electrical	FC 6000-6999
Duct without Damper and Misc. Mechanical	FC 7000-7999
Multiple Penetrations	FC 8000-8999

2. Non-Combustible Framed Walls - 1 or 2 Hour Rated
   F Rating = Wall Rating
   T Rating = 0
   L Rating = Penetrations in Smoke Barriers

Penetrating Item	UL System No.
No Penetrating Item	WL 0000-0999*
Metallic Pipe or Conduit	WL 1000-1999
Non-Metallic Pipe or Conduit	WL 2000-2999

Penetrating Item	UL System No.
Electrical Cables	WL 3000-3999
Cable Trays	WL 4000-4999
Insulated Pipes	WL 5000-5999
Bus Duct and Misc. Electrical	WL 6000-6999
Duct without Damper and Misc. Mechanical	WL 7000-7999
Multiple Penetrations	WL 8000-8999

3. Concrete or Masonry Floors and Walls - 1 or 2 Hour Rated
F Rating = Wall/Floor Rating
T Rating (Floors) = Floor Rating
L Rating = Penetrations in Smoke Barriers

Penetrating Item	UL System No.
No Penetrating Item	CAJ 0000-0999*
Metallic Pipe or Conduit	CAJ 1000-1999
Non-Metallic Pipe or Conduit	CAJ 2000-2999
Electrical Cables	CAJ 3000-3999
Cable Trays	CAJ 4000-4999
Insulated Pipes	CAJ 5000-5999
Bus Duct and Misc. Electrical	CAJ 6000-6999
Duct without Damper and Misc. Mechanical	CAJ 7000-7999
Multiple Penetrations	CAJ 8000-8999

*Alternate method of firestopping is patching opening to match original rated construction.

G. Any opening in walls or floors not covered by the listed series of numbers shall be coordinated with the firestopping manufacturer.

H. Any openings in floors or walls not described in the UL or listed by Intertek / Warnock Hersey Fire Resistance Directory, or outlined in manufacturer's information shall be sealed in a manner agreed upon by the Firestopping Manufacturer, Owner, and the Authority Having Jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Ensure all surfaces that contact seal materials are free of dirt, dust, grease, oil, rust, or loose materials. Clean and repair surfaces as required. Remove laitance and form-release agents from concrete.

B. Ensure substrate and penetrating items have been permanently installed prior to installing firestopping systems. Ensure penetrating items have been properly spaced and have proper clearance prior to installing firestopping systems.

C. Surfaces to which sealing materials are to be installed must meet the selected UL or Intertek / Warnock Hersey system substrate criteria.

D. Prime substrates where recommended in writing by through-penetration firestop system manufacturer. Confine primer to area of bond.

3.2 INSTALLATION

A. In existing construction, provide firestopping of openings prior to and after installation of penetrating items. Remove any existing coatings on surfaces prior to firestopping installation. Temporary firestopping shall consist of packing openings with fire resistant mineral wool for the full thickness of substrate, or an alternate method approved by the Authority Having Jurisdiction. All openings shall be temporarily firestopped immediately upon their installation and shall remain so until the permanent UL or listed by Intertek / Warnock Hersey listed firestopping system is installed.

B. Install penetration seal materials in accordance with printed instructions of the UL or Intertek / Warnock Hersey Fire Resistance Directory and with the manufacturer's printed application instructions.

C. Install dams as required to properly contain firestopping materials within openings and as required to achieve required fire resistance rating. Remove combustible damming after appropriate curing.

3.3 CLEANING AND PROTECTING

A. Clean excess fill materials adjacent to openings as Work progresses by methods and with cleaning materials that are approved in writing by through-penetration firestop system manufacturers and that do not cause damage.

B. Provide final protection and maintain conditions during and after installation that ensure that through-penetration firestop systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, remove damaged or deteriorated through-penetration firestop systems immediately and install new materials to produce systems complying with specified requirements.

3.4 INSPECTION

A. All penetrations shall be inspected by the manufacturer's representative to ensure proper installation.

B. Access to firestop systems shall be maintained for examination by the Authority Having Jurisdiction at their request.

C. Proceed with enclosing through-penetration firestop system with other construction only after inspection reports are issued and firestop installations comply with requirements.

D. The contractor shall allow for visual destructive review of 5% of installed firestop systems (minimum of one) to prove compliance with specifications and manufacturer's instructions and details. Destructive system removal shall be performed by the contractor and witnessed by the Architect/Engineer and manufacturer's factory representative. The Architect/Engineer shall have sole discretion of which firestop system installations will be reviewed. The contractor is responsible for all costs associated with this requirement including labor and material for removing and replacing the installed firestop system. If any firestop system is found to not be installed per manufacturer's specific instructions and details, all firestop systems are subject to destructive review and replacement at the Architect/Engineer's discretion and the contractor's expense.

END OF SECTION

SECTION 26 05 13
WIRE AND CABLE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Building wire
B. Remote control and signal cable
C. Fire rated cable

1.2 REFERENCES

A. NEMA WC 70 - Power Cables Rated 2,000V or Less for the Distribution of Electrical Energy

B. NFPA 70 - National Electrical Code (NEC)

C. UL 44 – Thermoset-Insulated Wires and Cables

D. UL 83 – Thermoplastic-Insulated Wires and Cables

E. UL 854 – Service-Entrance Cables

F. UL 1581 – Standard for Electrical Wires, Cables, and Flexible Cords

PART 2 - PRODUCTS

2.1 BUILDING WIRE

A. Feeders and Branch Circuits Larger Than 6 AWG: Copper, stranded conductor, 600 volt insulation, XHHW-2.

B. Feeders and Branch Circuits Larger than 6 AWG in Underground Conduit: Copper, stranded conductor, 600 volt insulation, XHHW-2.

C. Feeders and Branch Circuits 6 AWG and Smaller: Copper conductor, 600 volt insulation, THHN/THWN. 6 and 8 AWG, stranded conductor; smaller than 8 AWG, solid or stranded conductor, unless otherwise noted on the drawings.

D. Three conductor stranded coverall helical copper tape shield. Shield shall be terminated at both ends of cable with an approved termination.

E. Control Circuits: Copper, stranded conductor 600 volt insulation, THHN/THWN.

F. Each 120 and 277 volt branch circuit shall have a dedicated neutral conductor. Neutral conductors shall be considered current-carrying conductors for wire derating.

2.2 REMOTE CONTROL AND SIGNAL CABLE

A. Control Cable for Class 1 Remote Control and Signal Circuits: Copper conductor, 600 volt insulation, rated 60°C, individual conductors twisted together, shielded, and covered with a PVC jacket.

B. Control Cable for Class 2 or Class 3 Remote Control and Signal Circuits: Copper conductor, 300 volt insulation, rated 60ºC, individual conductors twisted together, shielded, and covered with a PVC jacket; UL listed.

C. Plenum Cable for Class 2 or Class 3 Remote Control and Signal Circuits: Copper conductor, 300 volt insulation, rated 60°C, individual conductors twisted together, shielded, and covered with a nonmetallic jacket; UL listed for use in air handling ducts, hollow spaces used as ducts, and plenums.

2.3 FIRE-RATED CABLE

A. Two-hour Fire Rated Mineral Insulated Cables: Copper conductor, 600 volt insulation, rated 90ºC, Type MI.

PART 3 - EXECUTION

3.1 WIRE AND CABLE INSTALLATION SCHEDULE

A. Above Accessible Ceilings:

1. Building wire shall be installed in raceways.

B. All Other Locations: Building wire in raceway.

C. Above Grade: All conductors installed above grade shall be type “THHN”.

D. Underground or In Slab: All conductors shall be type “THWN”.

E. Low Voltage Cable (less than 100 volts): Low voltage cable shall be installed in raceway.

3.2 WIRE FOR SPECIALIZED SYSTEMS

A. Wire for the following specialized systems shall be as designated on the drawings, or elsewhere in these specifications. If not designated on the drawings or specifications, the system manufacturer's recommendations shall be followed:

1. Fire alarm
2. Low voltage switching
3. Sound
4. Electronic control
5. Security
6. TV
7. Telephone
8. Data
9. Clock

3.3 CONTRACTOR CHANGES

A. The basis of design is copper conductors installed in raceway based on ambient temperature of 30°C, NEC Table 310.16. Service entrance and fire pump feeder conductors are based on copper conductor installed in underground electrical ducts, NEC Table B.310.15(B)(2)(7).

B. The Contractor shall be responsible for derating and sizing conductors and conduits to equal or exceed the ampacity of the basis of design circuits, if he/she chooses to use methods or materials other than the basis of design.

C. Underground electrical duct ampacity rating shall be in accordance with NEC Table B.310.15(B)(2)(7) or calculated in accordance with Annex B Application Information for Ampacity Calculation. The calculations and a sketch of the proposed installation shall be submitted prior to any conduit being installed.

D. Record drawing shall include the calculations and sketches.

3.4 GENERAL WIRING METHODS

A. Use no wire smaller than 12 AWG for power and lighting circuits, and no smaller than 14 AWG for control wiring.

B. Use no wire smaller than 18 AWG for low voltage control wiring (<100 volts).

C. Use 10 AWG conductor for 20 ampere, 120 volt branch circuit home runs longer than 75 feet, and for 20 ampere, 277 volt branch circuit home runs longer than 200 feet.

D. Use no wire smaller than 8 AWG for outdoor lighting circuits.

E. The ampacity of multiple conductors in one conduit shall be derated per NEC 310. In no case shall more than 4 conductors be installed in one conduit to such loads as motors larger than 1/4 HP, panelboards, motor control centers, etc.

F. Where installing parallel feeders, place an equal number of conductors for each phase of a circuit in same raceway or cable.

G. Splice only in junction or outlet boxes.

H. Neatly train and lace wiring inside boxes, equipment, and panelboards.

I. Make conductor lengths for parallel circuits equal.

J. All conductors shall be continuous in conduit from last outlet to their termination.

K. Terminate all spare conductors on terminal blocks, and label the spare conductors.

L. Cables or wires shall not be laid out on the ground before pulling.

M. Cables or wires shall not be dragged over earth or paving.

N. Care shall be taken so as not to subject the cable or wire to high mechanical stresses that would cause damage to the wire and cable.

O. At least six (6)-inch loops or ends shall be left at each outlet for installation connection of luminaires or other devices.

P. All wires in outlet boxes not connected to fixtures or other devices shall be rolled up, spliced if continuity of circuit is required, and insulated.

3.5 WIRING INSTALLATION IN RACEWAYS

A. Pull all conductors into a raceway at the same time. Use UL listed wire pulling lubricant for pulling 4 AWG and larger wires.

B. Install wire in raceway after interior of building has been physically protected from the weather and all mechanical work likely to injure conductors has been completed.

C. Pulling shall be continuous without unnecessary stops and starts with wire or cable only partially thru raceway.

D. Where reels of cable or wire are used, they shall be set up on jacks close to the point where the wire or cable enters the conduit or duct so that the cable or wire may be unreeled and run into the conduit or duct with a minimum of change in the direction of the bend.

E. Conductors shall not be pulled through conduits until plastering or masonry work is completed and conduits are free from moisture. Care shall be taken so that long pulls of wire or pulls around several bends are not made where the wire may be permanently stretched and the insulation damaged.

F. Only nylon rope shall be permitted to pull cables into conduit and ducts.

G. Completely and thoroughly swab raceway system before installing conductors.

H. Conductor Supports in Vertical Raceways:

1. Support conductors in vertical raceways in accordance with NEC 300.19 and Table 300.19(A) Spacing of Conductors Supports.

2. Supports shall be of insulated wedge type (OZ Gedney Type S, or equal) and installed in a tapered insulated bushing fitting or a metal woven mesh with a support ring that fits inside conduit fitting installed in an accessible junction box (Hubbell Kellems support grip or equal).

3.6 CABLE INSTALLATION

A. Provide protection for exposed cables where subject to damage.

B. Use suitable cable fittings and connectors.

C. Run all open cable parallel or perpendicular to walls, ceilings, and exposed structural members. Follow the routing as illustrated on the drawings as closely as possible. Cable routing on drawings scaled 1/4”=1’-0” or less shall be considered diagrammatical, unless noted otherwise. The correct routing, when shown diagrammatically, shall be chosen by the Contractor based on information in the contract documents; in accordance with the manufacturer’s written instructions, applicable codes, the NECA’s “Standard of Installation”, recognized industry standards; and coordinated with other contractors.

D. Open cable shall be supported by the appropriate size J-hooks or other means if called for on the drawings. Wire and cable from different systems shall not be installed in the same J-hook. J-hooks shall be sized with 20% spare capacity. J-hooks shall provide proper bend radius support for data cable and fiber cables. J-hooks shall be Caddy CAT or Mono Systems H-433 series.

E. Open cable installed above suspended ceilings shall not rest on the suspended ceiling construction, nor utilize the ceiling support system for wire and cable support.

F. J-hook supports shall be installed at a maximum of five-foot (5') intervals. All J-hooks shall be installed where completely accessible and not blocked by piping, ductwork, inaccessible ceilings, etc. J-hooks shall be independently rigidly attached to a structural element. J-hooks shall be installed to provide 2” horizontal separation and 6” vertical separation between systems.

G. Open cable shall only be installed where specifically shown on the drawings, or permitted in these specifications.

3.7 FIRE-RATED CABLE INSTRUCTIONS

A. Terminations of the fire-rated cable must be outside of the fire zone.

B. Fire-rated cable shall be installed according to the manufacturer’s recommendations.

3.8 WIRING CONNECTIONS AND TERMINATIONS

A. Splice and tap only in accessible junction boxes.

B. Use solderless, tin-plated copper, compression terminals (lugs) applied with circumferential crimp for copper conductor terminations, 8 AWG and larger.

C. Use solderless, tin-plated, compression terminals (lugs) applied with indenter crimp for copper conductor terminations, 10 AWG and smaller.

D. Use solderless pressure connectors with insulating covers for copper wire splices and taps, 8 AWG and smaller. For 10 AWG and smaller, use insulated spring wire connectors with plastic caps.

E. Use copper, compression connectors applied with circumferential crimp for copper wire splices and taps, 6 AWG and larger. Tape uninsulated conductors and connectors with electrical tape to 150 percent of the insulation value of conductor.

F. Thoroughly clean wires before installing lugs and connectors.

G. Make splices, taps and terminations to carry full ampacity of conductors without perceptible temperature rise.

H. Phase Sequence: All apparatus shall be connected to operate in the phase sequence A-B-C representing the time sequence in which the phase conductors so identified reach positive maximum voltage.

I. As a general rule, applicable to switches, circuit breakers, starters, panelboards, switchgear and the like, the connections to phase conductors are intended thus:

1. Facing the front and operating side of the equipment, the phase identification shall be:

a. Left to Right - A-B-C
b. Top to Bottom - A-B-C

J. Connection revisions as required to achieve correct rotation of motors shall be made at the load terminals of the starters or disconnect switches.

3.9 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Division 1.

B. Building Wire and Power Cable Testing: Perform an insulation-resistance test on each conductor with respect to ground and adjacent conductors. Test shall be made by means of a low-resistance ohmmeter, such as a "Megger". The applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. The test duration shall be one minute. Insulation resistance must be greater than 100 mega-ohm for 600 volt and 25 mega-ohm for 300 volt rated cables per NETA Acceptance Testing Standard. Verify uniform resistance of parallel conductors.

C. Inspect wire and cable for physical damage and proper connection.

D. Torque test conductor connections and terminations to manufacturer's recommended values.

E. Perform continuity test on all power and equipment branch circuit conductors. Verify proper phasing connections.

F. Protection of wire and cable from foreign materials:

1. It is the Contractor's responsibility to provide adequate physical protection to prevent foreign material application or contact with any wire or cable type. Foreign material is defined as any material that would negatively impact the validity of the manufacturer's performance warranty. This includes, but is not limited to, overspray of paint (accidental or otherwise), drywall compound, or any other surface chemical, liquid, or compound that could come in contact with the cable, cable jacket, or cable termination components.

G. Overspray of paint on any wire or cable will not be accepted. It shall be the Contractor's responsibility to replace any component containing overspray, in its entirety, at no additional cost to the project. Cleaning of the cables with harsh chemicals is not allowed.

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Equipment grounding system
B. Bonding system
C. Grounding electrode system

1.2 QUALITY ASSURANCE

A. Testing Agency Qualifications: Testing agency as defined by OSHA in 29 CFR 1910.7 or a member company of the International Electrical Testing Association and that is acceptable to authorities having jurisdiction.

B. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association to supervise on-site testing specified in Part 3.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with UL 467 Grounding and Bonding Equipment.

E. Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system.

F. Comply with NFPA 70; for overhead-line construction and medium-voltage underground construction, comply with IEEE/ANSI C2 National Electrical Safety Code (NESC).

1.3 SUBMITTALS

A. Submit shop drawings under provisions of Section 26 05 00.

B. Product Data: For the following:

1. Ground rods.
2. Chemical electrodes.

C. Field Test Reports: Submit written test reports to include the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Indicate layout of ground field, location of system grounding electrode connections, and routing of grounding electrode conductor and ground ring.

1.4 SUMMARY

A. This section includes grounding of electrical systems and equipment. Grounding requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

PART 2 - PRODUCTS

2.1 GROUNDING CONDUCTORS

A. For insulated conductors, comply with Division 26 Section 26 05 13 "Wire and Cable".

B. Material: Copper.

C. Equipment Grounding Conductors: Insulated with green-colored insulation.

D. Grounding Electrode Conductors: Stranded cable.

E. Underground Conductors: Bare, tinned, stranded, unless otherwise indicated.

F. Sizes and types below are typical. Adjust to suit Project conditions and requirements.

G. Copper Bonding Conductors: As follows:

1. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG copper conductor, 1/4 inch in diameter.

2. Bonding Conductor: No. 4 or No. 6 AWG, stranded copper conductor.

3. Bonding Jumper: Bare copper tape, braided bare copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

4. Tinned Bonding Jumper: Tinned-copper tape, braided copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

H. **[GB]:** Grounding Bus:

1. Bare, annealed copper bars of rectangular cross section, with insulators. 1/4” x 2” x 24”.

I. **[IBT]:** Intersystem Bonding Termination:

1. Copper bar, 1/4” x 2” x 24”. Provide with wall mounting brackets, insulators and pre-tapped holes.

2. Approved Manufacturers: Harger GBI Series, Erico B544 Series.

2.2 CONNECTOR PRODUCTS

A. Comply with UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items.

B. Connectors: Hydraulic compression type or exothermic-welded type, in kit form, and selected per manufacturer’s written instructions.

C. Bolted Connectors: Bolted-pressure-type connectors.

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel.

B. Concrete-Encased Grounding Electrode (Ufer): Fabricate according to NFPA 70, Paragraph 52-(3), using a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG or 20 feet (6.0 m) of 1/2” (13mm) steel reinforcing bar.

PART 3 - EXECUTION

3.1 CONNECTIONS

A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.

2. Make connections with clean, bare metal at points of contact.

3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.

4. Make aluminum-to-galvanized steel connections with tin-plated copper jumpers and mechanical clamps.

5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

B. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

C. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

D. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.

E. Noncontact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically non-continuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.

F. Structural Steel Connection: Exothermic-welded connections to structural steel. Coordinate with structure to provide physical protection.

G. Exothermic-welded connections or hydraulic compression connection. Use for underground connections, except those at test wells.

H. Connections at Test Wells: Use compression-type connectors on conductors and make two bolted- and clamped-type connections between conductors and ground rods.

I. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

J. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.2 INSTALLATION

A. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.

B. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage. Each grounding conductor that passes through a below grade wall must be provided with a waterstop.

C. Grounding electrode conductor (GEC) shall be protected from physical damage by rigid polyvinyl chloride conduit (PVC) in exposed locations.

D. Bonding Straps and Jumpers: Install so vibration by equipment mounted on vibration isolation hangers and supports is not transmitted to rigidly mounted equipment. Use exothermic-welded connectors for outdoor locations, unless a disconnect-type connection is required; then use a bolted clamp. Bond straps directly to the basic structure, taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.

E. In raceways, use insulated equipment grounding conductors.

F. Underground Grounding Conductors: Use copper conductor, No. 2/0 AWG minimum. Bury at least 24 inches below grade or bury 12 inches above duct bank when installed as part of the duct bank.

G. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, below access floors, and elsewhere as indicated, with bolted connections to form a continuous ground path.

3.3 EQUIPMENT GROUNDING SYSTEM

A. Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.

B. Install equipment grounding conductors in all feeders and circuits. Terminate each end on a grounding lug or bus.

3.4 BONDING SYSTEM

A. At building expansion joints, provide flexible bonding jumpers to connect to columns or beams on each side of the expansion joint.

B. Isolated Equipment Enclosure: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate equipment bonding conductor.

C. Exterior Metallic Pull and Junction Box Covers, Metallic Hand Rails: Bond to grounding system using flexible grounding conductors.

D. Bond metal ducts of dust collectors, particulate conveying, fume hoods, and other hazardous materials to the equipment grounding conductors of associated pumps, fans, or blowers. Use braided-type bonding straps. Provide braided bare copper bonding conductor in nonmetallic dust collector ductwork to each equipment inlet location, and bond to equipment.

E. Water Heater, Heat-Tracing, Metal Well Casing, and Heating Cables: Install a separate equipment grounding conductor to each electric water heater, heat-tracing, and anti-frost heating cable. Bond conductor to heater units, piping, well casing, connected equipment, and components.

F. Connect bonding conductors to metal water pipe using a suitable ground clamp. Make connections to flanged piping at street side of flange. Provide bonding jumper around water meter.

G. Signal and Communication Systems: For telephone, alarm, voice and data, and other communication systems, provide No. 6 AWG minimum insulated bonding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location. Leave 10 feet of slack conductor at terminal board.

H. Telecom Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-12-inch grounding bar.

I. Terminal Cabinets: Terminate bonding conductor on cabinet grounding terminal.

J. Remote control, signaling, and fire alarm circuits shall be bonded in accordance with the most recent version of the National Electric Code.

K. Metal Poles Supporting Outdoor Lighting Fixtures > 15 feet: Provide a grounding electrode in addition to installing a separate equipment grounding conductor with supply branch-circuit conductors.

3.5 GROUNDING ELECTRODE SYSTEM

A. Ground Ring (Counterpoise):

1. Ground the steel framework of the building with a driven ground rod at the base of every corner column and at intermediate exterior columns at average distances not more than 60 feet (18 m) apart. Provide a grounding conductor, electrically connected to each ground rod and to each steel column, extending around the perimeter of the building. Use tinned-copper conductor not less than No. 2 AWG for ground ring and for tap to building steel. Bury conductor not less than 30 inches (760 mm) below grade, 24 inches (600 mm) from building foundation, and 18 inches (459 mm) outside of roof drip line.

B. Supplementary Grounding Electrode: Use driven ground rod on exterior of building.

C. Provide bonding at Utility Company's metering equipment and pad mounted transformer.

D. Ground Rods: Install at least two rods spaced at least 20 feet from each other and located at least the same distance from other grounding electrodes.

1. Drive ground rods until tops are 12 inches below finished floor or final grade, unless otherwise indicated.

2. Interconnect ground rods with grounding electrode conductors. Use exothermic welds, except at test wells and as otherwise indicated. Make connections without exposing steel or damaging copper coating.

E. Metal Water Service Pipe: Provide insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes by grounding clamp connectors. Where a dielectric main water fitting is installed, connect grounding conductor to street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

F. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with grounding clamp connectors.

G. Bond each aboveground portion of natural gas metallic piping system at equipment locations. The equipment grounding conductor may serve as the bonding means.

H. Concrete-Encased Grounding Electrode (Ufer): Install concrete-encased grounding electrode encased in at least 2 inches (50mm) of concrete horizontally within the foundation that is in contact with the earth. If concrete foundation is less than 20 feet long, coil excess conductor within the base of the foundation. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to a grounding electrode external to concrete.

3.6 CONCRETE BUILDING GROUNDING SYSTEM

A. Provide a copper common grounding electrode conductor for the attachment of multiple separately derived systems in accordance with NEC 250.30(A)(4)(a) through 250.30(A)(4)(c). Individual grounding conductor taps from the separately derived systems to the common grounding electrode shall be sized in accordance with NEC 250.66. All tap connections shall be made in an accessible location in such a manner that common grounding electrode conductor remains without a splice or joint.

3.7 EQUIPOTENTIAL (MULTI-POINT) GROUNDING SYSTEM

A. Provide an equipotential grounding system in the following locations:

1. Class I Div 1 and Div 2 locations as required in NEC 501.30.
2. Critical patient care and special care areas as indicated on drawings.

B. The non-current-carrying metal parts of equipment, raceways and other enclosures shall be bonded to the grounding system.

3.8 FIELD QUALITY CONTROL

A. Inspect grounding and bonding system conductors and connections for tightness and proper installation.

1. Measure ground resistance from system neutral connection at service entrance to convenient ground reference points using suitable ground testing equipment. Resistance shall not exceed 5 ohms.

2. Testing: Engage a qualified testing agency to perform the following field quality-control testing:

a. After installing grounding system but before permanent electrical circuitry has been energized, test for compliance with requirements.

b. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells. Measure ground resistance not less than two full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests, by the fall-of-potential method according to IEEE 81.

c. Provide drawings locating each ground rod and ground rod assembly and other grounding electrodes, identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

1) Equipment Rated 500 kVA and Less: 10 ohms.
2) Equipment Rated 500 to 1000 kVA: 5 ohms.
3) Equipment Rated More Than 1000 kVA: 3 ohms.
4) Substations and Pad-Mounted Switching Equipment: 5 ohms.
5) Manhole Grounds: 10 ohms.

d. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect/Engineer promptly and include recommendations to reduce ground resistance.

END OF SECTION

SECTION 26 05 27
SUPPORTING DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Conduit and equipment supports
B. Fastening hardware
C. Concrete housekeeping pads

1.2 QUALITY ASSURANCE

A. Support systems shall be adequate for weight of equipment and conduit, including wiring, which they carry.

1.3 COORDINATION

A. Coordinate size, shape and location of concrete pads with Section on Cast-in-Place Concrete or Concrete Topping.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Allied Support Systems
B. Cooper B-Line
C. Erico, Inc.
D. Hilti
E. Power Fasteners

2.2 MATERIAL

A. Support Channel: Stainless steel for wet/damp locations; painted steel for interior/dry locations. All field cut ends shall be touched up with matching finish to inhibit rusting.

B. Hardware: Corrosion resistant.

C. Anchorage and Structural Attachment Components:

1. Strength: Defined in reports by ICBO Evaluation Service or another agency acceptable to Authorities Having Jurisdiction.

a. Structural Safety Factor: Strength in tension and shear of components used shall be at least two times the maximum seismic forces to which they will be subjected.

2. Through Bolts: Structural type, hex head, high strength. Comply with ASTM A 325.

3. Welding Lugs: Comply with MSS-SP-69, Type 57.

4. Beam clamps for Steel Beams and Joists: Double sided. Single-sided type is not acceptable.

5. Bushings for Floor-Mounted Equipment Anchors: Neoprene units designed for seismically rated rigid equipment mountings, and matched to the type and size of anchor bolts and studs used.

6. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for seismically rated rigid equipment mountings, and matched to the type and size of attachment devices used.

7. Concrete Anchors: Fasten to concrete using cast-in or post-installed anchors designed per the requirements of Appendix D of ACI 318-08. Post-installed anchors shall be qualified for use in cracked concrete by ACI-355.2.

8. Masonry Anchors: Fasten to concrete masonry units with expansion anchors or self-tapping masonry screws. For expansion anchors into hollow concrete block, use sleeve-type anchors designed for the specific application. Do not fasten in masonry joints. Do not use powder actuated fasteners, wooden plugs, or plastic inserts.

D. Conduit Sleeves and Lintels:

1. Each Contractor shall provide, to the General Contractor for installation, lintels for all openings required for the Contractor's work in masonry walls and conduit sleeves for floors, unless specifically shown as being by others.

2. Refer to Structural General Notes for lintel requirements in masonry construction.

3. Fabricate all lintels from structural steel shapes or as indicated on the drawings. All lintels and grouped wall openings shall be approved by the Architect or Structural Engineer.

4. Fabricate all sleeves from standard weight black steel pipe. Provide continuous sleeve. Cut or split sleeves are not acceptable. Sleeves through concrete walls may be high density polyethylene pipe penetration sleeve with a water stop collar, suitable for use with Link-Seal mechanical seals. Century-Line Model CS.

5. Sleeves through the floors on exposed risers shall be flush with the ceiling, with planed squared ends extending 1" above the floor in unfinished areas, and flush with the floor in finished areas, to accept spring closing floor plates.

6. Sleeves shall not penetrate structural members without approval from the Structural Engineer.

7. Openings through unexcavated floors and/or foundation walls below the floor shall have a smooth finish with sufficient annular space around material passing through opening so slight settling will not place stress on the material or building structure.

8. Install all sleeves concentric with conduits. Secure sleeves in concrete to wood forms. This Contractor is responsible for sleeves dislodged or moved when pouring concrete.

9. Where conduits rise through concrete floors that are on earthen grade, provide 3/4" resilient expansion joint material (asphalt and cork) wrapped around the pipe, the full depth of concrete, at the point of penetration. Secure to prevent shifting during concrete placement and finishing.

10. Size sleeves large enough to allow expansion and contraction movement.

E. Concrete Housekeeping Pads:

1. Concrete bases for all floor mounted equipment and wall mounted equipment which is surface mounted and extends to within 6" of the finished floor, unless shown otherwise on the drawings, shall be 3-1/2" thick concrete.

2. Bases shall extend 3" on all sides of the equipment (6" larger than factory base).

3. Where the base is less than 12" from a wall, the base shall be carried to the wall to prevent a "dirt-trap".

4. Concrete materials and workmanship required for the Contractor's work shall be provided by him. Materials and workmanship shall conform to the applicable standards of the Portland Cement Association. Reinforce with 6" x 6", W1.4-W1.4 welded wire fabric. Concrete shall withstand 3,000 pounds compression per square inch at twenty-eight days.

F. Rooftop Support System:

1. Provide pre-fabricated roof supports for all conduit and equipment installed above the roof. Support all conduit and equipment a minimum of 4" above roof.

2. Support system shall be compatible with single ply, bituminous, metal, and spray foam roof systems. The base shall be rounded to prevent damage to the roof, and drainage holes shall prevent ponding of water in the support.

3. All metal components shall be hot dipped galvanized. Mounting hardware shall be stainless steel or hot dipped galvanized. Support shall be UV, corrosion, and freeze/thaw resistant. Support shall include orange paint, reflective safety orange accents, or similar markings for increased visibility.

4. Acceptable Products: Anvil International HBS-Base Series, Cooper B-Line Dura-Blok, Erico Caddy Pyramid 50, 150, 300, or 600 (to match load).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fasten hanger rods, conduit clamps, and outlet and junction boxes to building structure using expansion anchors in concrete and beam clamps on structural steel.

B. Use toggle bolts or hollow wall fasteners in hollow masonry, plaster, or gypsum board partitions and walls; expansion anchors or preset inserts in solid masonry walls; self-drilling anchors or expansion anchor on concrete surfaces; sheet metal screws in sheet metal studs; and wood screws in wood construction.

C. Do not fasten supports to ceiling systems, piping, ductwork, mechanical equipment, or conduit, unless otherwise noted.

D. Do not use powder-actuated anchors without specific permission.

E. Do not drill structural steel members.

F. Fabricate supports from structural steel or steel channel, rigidly welded or bolted to present a neat appearance. Use hexagon head bolts with spring lock washers under all nuts.

G. In wet locations and on all building floors below exterior earth grade install free-standing electrical equipment on concrete pads.

H. Install cabinets and panelboards with minimum of four anchors. Provide horizontal backing/support framing in stud walls for rigid mounting.

I. Bridge studs top and bottom with channels to support flush-mounted cabinets and panelboards in stud walls.

J. Do not exceed 25 lbs. per hanger and a minimum spacing of 2'-0" on center when attaching to metal roof decking (excludes concrete on metal deck). This 25 lbs. load and 2'-0" spacing include adjacent electrical and mechanical items hanging from deck. If the hanger restrictions cannot be achieved, supplemental framing off steel framing will need to be added.

K. Refer to Section 26 05 33 for special conduit supporting requirements.

3.2 FINISH

A. Prime coat exposed steel hangers and supports. Hangers and supports in crawl spaces, pipe shafts, and above suspended ceiling spaces are not considered exposed.

B. Trim all ends of exposed field fabricated steel hangers, slotted channel and threaded rod to within 1" of support or fastener to eliminate potential injury to personnel unless shown otherwise on the drawings. Smooth ends and install elastomeric insulation with two coats of latex paint if exposed steel is within 6'-6" of finish floor and presents potential injury to personnel.

END OF SECTION

SECTION 26 05 33
CONDUIT AND BOXES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Rigid metallic conduit and fittings
B. Intermediate metallic conduit and fittings
C. Electrical metallic tubing and fittings
D. Flexible metallic conduit and fittings
E. Liquidtight flexible metallic conduit and fittings
F. Rigid polyvinyl chloride conduit and fittings
G. High density polyethylene conduit and fittings
H. Wall and ceiling outlet boxes
I. Electrical connection
J. Pull and junction boxes
K. Rough-ins
L. Handholes
M. Accessories

1.2 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI C80.1 - Rigid Steel Conduit, Zinc-Coated
2. ANSI C80.3 - Electrical Metallic Tubing, Zinc-Coated and Fittings
3. ANSI C80.4 - Fittings for Rigid Metal Conduit and Electrical Metallic Tubing
4. ANSI C80.6 – Intermediate Metal Conduit, Zinc Coated
5. ANSI/NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports
6. ANSI/NEMA OS 2 - Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports

B. Federal Specifications (FS):

1. A–A–50553A – Fittings for Conduit, Metal, Rigid, (Thick-Wall and Thin-Wall (EMT) Type
2. A–A–55810 – Specification for Flexible Metal Conduit

C. NECA “Standards of Installation”

D. National Electrical Manufacturers Association (NEMA):

1. ANSI/NEMA FB 1 – Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable
2. RN 1 – Polyvinyl chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
3. TC 2 – Electrical Polyvinyl Chloride (PVC) Conduit
4. TC 9 – Fittings for PVC Plastic Utilities Duct for Underground Installation

E. NFPA 70 – National Electrical Code (NEC)

F. Underwriters Laboratories (UL): Applicable Listings

1. UL 1 – Flexible Metal Conduit
2. UL 6 – Rigid Metal Conduit
3. UL 360 – Liquid Tight Flexible Steel Conduit
4. UL514-B – Conduit Tubing and Cable Fittings
5. UL651-A – Type EB and a PVC Conduit and HDPE Conduit

6. UL651-B – Continuous Length HDPE Conduit
7. UL746A – Standard for Polymeric Materials – Short Term Property Evaluations
8. UL797 – Electrical Metal Tubing
9. UL1242 – Intermediate Metal Conduit

G. American Standard of Testing and Materials (ASTM):

1. ASTM D 570 - Standard Test Method for Water Absorption of Plastics
2. ASTM D 638 - Standard Test Method for Tensile Properties of Plastics
3. ASTM D 648 - Standard Test Method for Deflection Temperature of Plastics under Flexural Load in the Edge Wise Position
4. ASTM D 2412 - Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
5. ASTM D 2447 - Standard Specification for Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter
6. ASTM D 3350 - Standard Specification for Polyethylene Plastic Pipe and Fittings Material

H. Definitions:

1. Fittings: Conduit connection or coupling.

2. Body: Enlarged fittings with opening allowing access to the conductors for pulling purposes only.

3. Mechanical Spaces: Enclosed areas, usually kept separated from the general public, where the primary use is to house service equipment and to route services. These spaces generally have exposed structures, bare concrete and non-architecturally emphasized finishes.

4. Finished Spaces: Enclosed areas where the primary use is to house personnel and the general public. These spaces generally have architecturally emphasized finishes, ceilings and/or floors.

5. Concealed: Not visible by the general public. Often indicates a location either above the ceiling, in the walls, in or beneath the floor slab, in column coverings, or in the ceiling construction.

6. Above Grade: Not directly in contact with the earth. For example, an interior wall located at an elevation below the finished grade shall be considered above grade but a wall retaining earth shall be considered below grade.

7. Slab: Horizontal pour of concrete used for the purpose of a floor or sub-floor.

1.3 SUBMITTALS

A. Include fittings and conduits 1.5" and larger in coordination files. Include all in--floor and underfloor conduit in coordination files. Refer to Section 26 05 00 for coordination drawing requirements.

PART 2 - PRODUCTS

2.1 RIGID METALLIC CONDUIT (RMC) AND FITTINGS

A. Acceptable Manufacturers:

1. Acceptable Manufacturers: Allied, LTV, Steelduct, Wheatland Tube Co, O-Z Gedney, or approved equal.

2. Acceptable Manufacturers of RMC Conduit Fittings: Appleton Electric, O-Z/Gedney Co., Electroline, Raco, Bridgeport, Midwest, Regal, Thomas & Betts, Crouse-Hinds, Killark, or approved equal.

B. Minimum Size Galvanized Steel: 3/4 inch (19mm), unless otherwise noted.

C. Fittings and Conduit Bodies:

1. End Bell Fittings: Malleable iron, hot dip galvanized, threaded flare type with provisions for mounting to form.

2. Expansion Joints: Malleable iron and hot dip galvanized providing a minimum of 4 inches of movement. Fitting shall be watertight with an insulating bushing and a bonding jumper.

3. Expansion Joint for Concrete Encased Conduit: Neoprene sleeve with bronze end coupling, stainless steel bands and tinned copper braid bonding jumper. Fittings shall be watertight and concrete-tight.

4. Conduit End Bushings: Malleable iron type with molded-on high impact phenolic thermosetting insulation. Where required elsewhere in the contract documents, bushing shall be complete with ground conductor saddle and clamp. **High impact phenolic threaded type bushings are not acceptable.**

5. All other fittings and conduit bodies shall be of malleable iron construction and hot dip galvanized.

D. PVC Externally Coated Conduit: Compliant with UL 6, ANSI C80.1 and NEMA RN 1; rigid galvanized steel conduit with external 40 mil PVC coating and internal 2 mil urethane coating surface. All fittings and conduit bodies shall be complete with coating. Threads shall be hot galvanized and coated with a clear coat of urethane. The PVC coated system shall include necessary PVC coated fittings, boxes and covers to form a complete encapsulated system. Acceptable Manufacturers: Robroy, T&B Ocal or approved equal.

2.2 INTERMEDIATE METALLIC CONDUIT (IMC) AND FITTINGS

A. Minimum Size Galvanized Steel: 3/4 inch, unless otherwise noted.

B. Acceptable Manufacturers: Allied, LTV, Steelduct, Wheatland Tube Co, O-Z Gedney, or approved equal.

C. Fittings and Conduit Bodies:

1. End Bell Fittings: Malleable iron, hot dip galvanized, threaded flare type with provisions for mounting to form.

2. Expansion Joints: Malleable iron and hot dip galvanized providing a minimum of 4 inches of movement. Fitting shall be watertight with an insulating bushing and a bonding jumper.

3. Expansion Joint for Concrete Encased Conduit: Neoprene sleeve with bronze end coupling, stainless steel bands and tinned copper braid bonding jumper. Fittings shall be watertight and concrete-tight.

4. Conduit End Bushings: Malleable iron type with molded-on high impact phenolic thermosetting insulation. Where required elsewhere in the contract documents, bushing shall be complete with ground conductor saddle and clamp. **High impact phenolic threaded type bushings are not acceptable.**

5. All other fittings and conduit bodies shall be of malleable iron construction and hot dip galvanized.

2.3 ELECTRICAL METALLIC TUBING (EMT) AND FITTINGS

A. Minimum Size Electrical Metallic Tubing: 3/4 inch, unless otherwise noted.

B. Acceptable Manufacturers of EMT Conduit: Allied, LTV, Steelduct, Wheatland Tube Co, or approved equal.

C. Fittings and Conduit Bodies:

1. 2" Diameter or Smaller: Compression type of steel designed for their specific application.

2. Larger than 2": Compression type of steel designed for their specific application.

3. Acceptable Manufacturers of EMT Conduit Fittings: Appleton Electric, O-Z/Gedney Co., Electroline, Raco, Bridgeport, Midwest, Regal, Thomas & Betts, or approved equal.

2.4 FLEXIBLE METALLIC CONDUIT (FMC) AND FITTINGS

A. Minimum Size Galvanized Steel: 3/4 inch, unless otherwise noted. Lighting branch circuit wiring to an individual luminaire may be a manufactured, UL listed 3/8" flexible metal conduit and fittings with #14 AWG THHN conductors and an insulated ground wire. Maximum length of 3/8" FMC shall be six (6) feet.

B. Acceptable Manufacturers: American Flex, Alflex, Electri-Flex Co, or approved equal.

C. Construction: Flexible steel, approved for conduit ground, zinc coated, threadless type formed from a continuous length of spirally wound, interlocked zinc coated strip steel. Provide a separate equipment grounding conductor when used for equipment where flexibility is required.

D. Fittings and Conduit Bodies:

1. Threadless hinged clamp type, galvanized zinc coated cadmium plated malleable cast iron or screw-in type, die-cast zinc.

2. Fittings and conduit bodies shall include plastic or cast metal inserts supplied by the manufacturer to protect conductors from sharp edges.

3. Acceptable Manufacturers: O-Z/Gedney Co., Thomas & Betts, Appleton Electric, Electroline, Bridgeport, Midwest, Regal, or approved equal.

2.5 LIQUIDTIGHT FLEXIBLE METALLIC CONDUIT (LFMC) AND FITTINGS

A. Acceptable Manufacturers: Anaconda Type UA, Electri-Flex Type LA, Alflex, Carlon (Lamson & Sessions), or approved equal.

B. Construction: Flexible steel, approved for conduit ground, zinc coated, threadless type formed from a continuous length of spirally wound, interlocked zinc coated strip steel and an extruded PVC cover.

C. Fittings and Conduit Bodies:

1. Watertight, compression type, galvanized zinc coated cadmium plated malleable cast iron, UL listed.

2. Fittings and conduit bodies shall include plastic or cast metal inserts supplied by the manufacturer to protect conductors from sharp edges.

3. Acceptable Manufacturers: Appleton Electric, O-Z/Gedney Co., Electroline, Bridgeport, Thomas & Betts, Midwest, Regal, Carlon (Lamson & Sessions), or approved equal.

2.6 RIGID NON-METALLIC CONDUIT (PVC) AND FITTINGS

A. Minimum Size Rigid Smooth-Wall Nonmetallic Conduit: 3/4 inch, unless otherwise noted.

B. Acceptable Manufacturers: Carlon (Lamson & Sessions) Type 40, Cantex, J.M. Mfg., or approved equal.

C. Construction: Schedule 40 and Schedule 80 rigid polyvinyl chloride (PVC), UL labeled for 90°C.

D. Fittings and Conduit Bodies: NEMA TC 3; sleeve type suitable for and manufactured especially for use with the conduit by the conduit manufacturer.

E. Plastic cement for joining conduit and fittings shall be provided as recommended by the manufacturer.

2.7 HIGH DENSITY POLYETHYLENE

A. Minimum Size: 2 inch, unless noted otherwise.

B. Acceptable Manufacturers: Carlon, Chevron Phillips Chemical Company, or approved equal.

C. Materials used for the manufacture of polyethylene pipe and fittings shall be extra high molecular weight, high-density polyethylene resin. The material shall be listed by PPI (Plastic Pipe Institute) and shall meet the following resin properties:

ASTM Test	Description	Values HDPE
D-1505	Density g/CM 3	< .941
D-1238	Melt Index, g/10 min Condition E	> .55 grams/10 min.
D-638	Tensile Strength at yield (psi)	3000 min.
D-1693	Environmental Stress Crack Resistance Condition B, F 20	96 hrs.
D-790	Flexural Modulus, MPa (psi)	< 80,000
D-746	Brittleness Temperature	-75°C Max

D. The pipe shall contain no recycled compound except that generated in the manufacturer's own plant from resin of the same raw material, including both the base resin and coextruded resin. The pipe shall be homogeneous throughout and free of visible cracks, holes, voids, foreign inclusions, or other defects that may affect the wall integrity.

E. Fitting and Conduit Bodies:

1. Directional Bore and Plow Type Installation: Electrofusion or Universal Aluminum threaded couplings. Tensile strength of coupled pipe must be greater than 2,000 lbs.

2. For all other type of installation: Coupler must provide a water tight connection. The tensile strength of coupled pipe must be greater than 1,000 lbs.

3. E-loc type couplings are not acceptable in any situations.

4. Acceptable Manufacturers: ARCON, Carlon, or approved equal.

2.8 OUTLET BOXES

A. Sheet Metal Outlet Boxes: ANSI/NEMA OS 1; galvanized steel, minimum of 14 gauge, with 1/2 inch male fixture studs where required.

B. Nonmetallic Outlet Boxes: ANSI/NEMA OS 2.

C. Cast Boxes: NEMA FB1, Type FD, Aluminum or cast feralloy, deep type, gasketed cover, threaded hubs.

D. Outlet boxes for luminaires to be not less than 1-1/2" deep, deeper if required by the number of wires or construction. The box shall be coordinated with surface luminaires to conceal the box from view or provide a finished trim plate.

E. Switch outlet boxes for local light control switches, dimmers and occupancy sensors shall be 4 inches square by 2-1/8 inches deep, with raised cover to fit flush with finish wall line. Multiple gang switch outlets shall consist of the required number of gang boxes appropriate to the quantity of switches comprising the gang. Where walls are plastered, provide a plaster raised cover. Where switch outlet boxes occur in exposed concrete block walls, boxes shall be installed in the block cavity with a raised square edge tile cover of sufficient depth to extend out to face of block or masonry boxes.

F. Outlet boxes for telephone substations in walls and columns shall be 4 inches square and 2-1/8 inches deep with single gang raised cover to fit flush with finished wall line equipped with flush telephone plate.

G. Wall or column receptacle outlet boxes shall be 4 inches square with raised cover to fit flush with finished wall line. Boxes in concrete block walls shall be installed the same as for switch boxes in block walls.

2.9 [ECONN]: ELECTRICAL CONNECTION

A. Electrical connection to equipment and motors, sized per NEC. Coordinate requirements with contractor furnishing equipment or motor. Refer to specifications and general installation notes for terminations to motors.

2.10 [JB]: PULL AND JUNCTION BOXES

A. Sheet Metal Boxes: ANSI/NEMA OS 1; galvanized steel.

B. Sheet metal boxes larger than 12 inches in any dimension that contain terminations or components: Continuous hinged enclosure with 1/4 turn latch and white back panel for mounting terminal blocks and electrical components.

C. Cast Metal Boxes for Outdoor and Wet Location Installations: NEMA 250; Type 4 and Type 6, flat-flanged, surface-mounted junction box, UL listed as raintight. Galvanized cast iron box and cover with ground flange, neoprene gasket, and stainless steel cover screws.

D. Cast Metal Boxes for Underground Installations: NEMA 250; Type 4, inside flanged, recessed cover box for flush mounting, UL listed as raintight. Galvanized cast iron box and plain cover with neoprene gasket and stainless steel cover screws.

E. Flanged type boxes shall be used where installed flush in wall.

2.11 HANDHOLES

A. **[HH-1]**: Handhole, composite polymer concrete body and cover. Stainless steel hardware. Bolted non-skid cover rated for 20,000 pounds. Design load occasional non-deliberate vehicular traffic. Stack units to achieve depth shown on plans. Units in landscaped areas shall be green in color. 11”W, 18”L, 18”D or dimensions as shown on plans.

1. Approved Manufacturers:

a. Hubbell/Quazite PG####BB18, PG####HA00
b. Carson Industries H Series
c. Armorcast
d. Highline Products
e. Synertech

B. **[HH-2]**: Handhole, cast iron, hot dipped galvanized with checkered cover sidewalk weatherproof box, flat neoprene cover gasket. Stainless steel screw hardware. Mounted flush in concrete. 17”W, 18”L, 12”D or dimensions as shown on plans.

1. Approved Manufacturers:

a. Appleton Electric WYT Series, WYT 181212
b. OZ Gedney YT Series
c. Crouse Hinds WJBF Series

C. **[HH-3]**: Handhole, concrete traffic box and galvanized steel checkered cover. Stainless steel hardware. Bolted cover and box rated for H/20 vehicular traffic. Reinforced concrete slab for bottom. 17”W, 18”L, 24”D or dimensions as shown on plans.

1. Approved Manufacturer: Oldcastle Precast B1017 Box

2.12 ACCESSORIES

A. Fire Rated Moldable Pads: UL #9700, moldable sheet putty at required thickness on all five sides of back boxes. Kinetics Noise Control – IsoBacker Pad, SpecSeal – SSP Putty and Pads, 3M #MPP-4S or equal.

B. Sound Barrier Insulation Pads: Mastic, non-hardening, sheet material, minimum 1/8" thickness applied to all five sides of back boxes. Kinetics Noise Control – SealTight Backer Pad, L.H. DOTTIE Co., #68 or equal.

PART 3 - EXECUTION

3.1 INSTALLATION TRAINING

A. PVC coated rigid metal conduit and reinforced thermosetting resin conduit (RTRC) manufacturers shall provide Contractor installation training for field cutting, joint preparation, joint assembly, field bending, and field cut sealing.

3.2 CONDUIT SIZING

A. Size conduit as shown on the drawings and specifications. Where not indicated in the contract documents, conduit size shall be according to NEC. Conduit and conductor sizing shall be coordinated to limit conductor fill to less than 40%, maintain conductor ampere capacity as required by the NEC (to include enlarged conductors due to temperature and quantity derating values) and to prevent excessive voltage drop and pulling tension due to long conduit/conductor lengths.

B. Minimum Conduit Size (Unless Noted Otherwise):

1. Above Grade: 3/4 inch. (The use of 1/2 inch would be allowed for installation conduit to individual light switches, individual receptacles and individual fixture whips from junction box.)
2. Below Grade 5' or less from Building Foundation: 1 inch.
3. Below Grade More than 5' from Building Foundation: 1 inch.
4. Telecommunication Conduit: 1 inch.
5. Low Voltage Systems Conduit: 3/4" inch.
6. Controls Conduit: 1/2 inch.

C. Conduit sizes shall change only at the entrance or exit to a junction box, unless specifically noted on the drawings.

3.3 CONDUIT ARRANGEMENT

A. In general, conduit shall be installed concealed in walls, in finished spaces and where possible or practical, or as noted otherwise. Conduit shall be installed parallel or perpendicular to walls, ceilings, and exposed structural members. In unfinished spaces, mechanical and utility areas, conduit may run either concealed or exposed as conditions dictate and as practical unless noted otherwise on drawings. Installation shall maintain headroom in exposed vicinities of pedestrian or vehicular traffic.

B. Exposed conduit on exterior walls or above roof will not be allowed without prior written approval of Architect/Engineer. A drawing of the proposed routing and a photo of the location shall be submitted 14 days prior to start of conduit rough-in. Routing shall be shown on coordination drawings.

C. Conduit shall not share the same cell as structural reinforcement in masonry walls.

D. Contractor shall adapt his work to the job conditions and make such changes as required and permitted by the Architect/Engineer, such as moving to clear beams and joists, adjusting at columns, avoiding interference with windows, etc., to permit the proper installation of other mechanical and/or electrical equipment.

E. Contractor shall cooperate with all Contractors on the project. He shall obtain details of other Contractor's work in order to ensure fit and avoid conflict. Any expense due to the failure of This Contractor to do so shall be paid for in full by him. The other trades involved as directed by the Architect/Engineer shall perform the repair of work damaged as a result of neglect or error by This Contractor. The resultant costs shall be borne by This Contractor.

3.4 CONDUIT SUPPORT

A. Conduit runs installed above a suspended ceiling shall be properly supported. In no case shall conduit rest on the suspended ceiling construction, nor utilize ceiling support system for conduit support.

B. Conduit shall not be supported from ductwork, water, sprinkler piping, or other non-structural members, unless approved by the Architect/Engineer. All supports shall be from structural slabs, walls, structural members, and bar joists, and coordinated with all other applicable contractors, unless noted otherwise.

C. Conduit shall be held in place by the correct size of galvanized one-hole conduit clamps, two-hole conduit straps, patented support devices, clamp back conduit hangers, or by other means if called for on the drawings.

D. Support individual horizontal raceways with separate, malleable-iron pipe hangers or clamps.

E. Spring-steel conduit clips specifically designed for supporting single conduits or tubing may be used in lieu of malleable-iron hangers for 1" and smaller raceways serving lighting and receptacle branch circuits above accessible ceilings and for securing raceways to slotted channel and angle supports.

F. Group conduits in parallel runs where practical and use conduit racks or trapeze hangers constructed of steel channel, suspended with threaded solid rods or wall mounted from metal channels with conduit straps or clamps. Provide space in each rack or trapeze for 25% additional conduits.

G. Do not exceed 25 lbs. per hanger and a minimum spacing of 2’-0” on center when attaching to metal roof decking (excludes concrete on metal deck). This 25 lbs. load and 2’-0” spacing include adjacent electrical and mechanical items hanging from deck. If the hanger restrictions cannot be achieved, supplemental framing off steel framing will need to be added.

H. Arrange supports in vertical runs so the weight of raceways and enclosed conductors is carried entirely by raceway supports, with no weight load on raceway terminals.

I. Supports for metallic conduit shall be no greater than 10 feet. A smaller interval may be used if necessitated by building construction, but in no event shall support spans exceed the NEC requirements. Conduit shall be securely fastened within 3 feet of each outlet box, junction box, device box, cabinet, or fitting.

J. Supports of flexible conduit shall be within 12 inches of each outlet box, junction box, device box, cabinet, or fitting and at intervals not to exceed 4.5 feet.

K. Supports for non-metallic conduit shall be at sufficiently close intervals to eliminate any sag in the conduit. The manufacturer's recommendations shall be followed, but in no event shall support spans exceed the NEC requirements.

L. Where conduit is to be installed in poured concrete floors or walls, provide concrete-tight conduit inserts securely fastened to forms to prevent conduit misplacement.

M. Finish:

1. Prime coat exposed steel hangers and supports. Hangers and supports in crawl spaces, pipe shafts, and above suspended ceiling spaces are not considered exposed.

2. Trim all ends of exposed field fabricated steel hangers, slotted channel and threaded rod to within 1" of support or fastener to eliminate potential injury to personnel unless shown otherwise on the drawings. Smooth ends and install elastomeric insulation with two coats of latex paint if exposed steel is within 6'-6" of finish floor and presents potential injury to personnel.

3.5 CONDUIT INSTALLATION

A. Conduit Connections:

1. Shorter than standard conduit lengths shall be cut square using industry standards. The ends of all conduits cut shall be reamed or otherwise finished to remove all rough edges.

2. Metallic conduit connections in slab on grade installation shall be sealed and one coat of rust inhibitor primer applied after the connection is made.

3. Where conduits with tapered threads cannot be coupled with standard couplings, then approved split or Erickson couplings shall be used. Running threads will not be permitted.

4. Install expansion/deflection joints where conduit crosses structure expansion/seismic joints.

B. Conduit terminations for all low voltage wiring shall have nylon bushings installed on each end of every conduit run.

C. Conduit Bends:

1. Use a hydraulic one-shot conduit bender or factory elbows for bends in conduit 2" in size or larger. All steel conduit bending shall be done cold; no heating of steel conduit shall be permitted.

2. All bends of rigid polyvinyl chloride conduit (PVC) shall be made with the manufacturer's approved bending equipment. The use of spot heating devices will not be permitted (i.e. blow torches).

3. A run of conduit shall not contain more than the equivalent of four (4) quarter bends (360°), including those bends located immediately at the outlet or body.

4. Telecommunications conduits shall have no more than two (2) 90 degree bends between pull points and contain no continuous sections longer than 100 feet. Insert pull points or pull boxes for conduits exceeding 100 feet in length.

   a. A third bend is acceptable if:

      1) The total run is not longer than (33) feet.
      2) The conduit size is increased to the next trade size.

5. Telecommunications pull boxes shall not be used in lieu of a bend. Align conduits that enter into the pull box from opposite ends with each other. Pull box size shall be twelve (12) times the diameter of the largest conduit. Slip sleeves or gutters can be used in place of a pull box.

6. Telecommunications conduit bend radius shall be six (6) times the diameter for conduits under 2" and ten (10) times the diameter for conduits over 2".

7. Rigid polyvinyl chloride conduit (PVC) runs longer than 100 feet or runs which have more than two 90° equivalent bends (regardless of length) shall use rigid metal or RTRC factory elbows for bends.

8. Use conduit bodies to make sharp changes in direction (i.e. around beams).

D. Conduit Placement:

1. Conduit shall be mechanically continuous from source of current to all outlets. Conduit shall be electrically continuous from source of current to all outlets, unless a properly sized grounding conductor is routed within the conduit. All metallic conduits shall be bonded per the NEC.

2. Route exposed conduit and conduit above suspended ceilings (accessible or not) parallel/perpendicular to the building structural lines, and as close to building structure as possible. Wherever possible, route horizontal conduit runs above water and steam piping.

3. Route conduit through roof openings provided for piping and ductwork where possible. If not provided or routing through provided openings is not possible, route through roof jack with pitch pocket. Coordinate roof penetrations with other trades.

4. Conduits, raceway, and boxes shall not be installed in concealed locations in metal deck roofing or less than 1.5” below bottom of roof decking.

5. Avoid moisture traps where possible. Where unavoidable, provide a junction box with drain fitting at conduit low point.

6. All conduits through walls shall be grouted or sealed into openings. Where conduit penetrates firewalls and floors, seal with a UL listed sealant. Seal penetrations with intumescent caulk, putty, or sheet installed per manufacturer's recommendations. All materials used to seal penetrations of firewalls and floors shall be tested and certified as a system per ASTM E814 Standard for fire tests or through-penetration fire stops as manufactured by 3M or approved equal.

7. CONTRACTOR SHALL BE RESPONSIBLE FOR ALL OPENINGS REQUIRED IN MASONRY OR EXTERIOR WALLS UNDER THIS DIVISION. A QUALIFIED MASON AT THE EXPENSE OF THIS CONTRACTOR SHALL REPAIR ALL OPENINGS TO MATCH EXISTING CONDITIONS.

8. Seal interior of conduit at exterior entries, air handling units, coolers/freezers, etc., and where the temperature differential can potentially be greater than 20°F, to prevent moisture penetration. Seal shall be placed where conduit enters warm space. Conduit seal fitting shall be a drain/seal, with sealing compound, equal to O-Z/Gedney type EYD.

9. Horizontal conduit routing through slabs above grade:

   a. No conduits are allowed in concrete on metal deck unless expressly approved in writing by the Structural Engineer.

   b. No conduits are allowed to be routed horizontally through slabs above grade.

10. Do not route conduits across each other in slabs on grade.

11. Rigid polyvinyl chloride conduit (PVC) shall be installed when material surface temperatures and ambient temperature are greater than 40°F.

12. Where rigid polyvinyl chloride conduit (PVC) is used below grade, in a slab, below a slab, etc., a transition to rigid galvanized steel or PVC-coated steel conduit shall be installed before conduit exits earth. The metallic conduit shall extend a minimum of 6" into the surface concealing the non-metallic conduit.

13. Contractor shall provide suitable mechanical protection around all conduits stubbed out from floors, walls or ceilings during construction to prevent bending or damaging of stubs due to carelessness with construction equipment.

14. Contractor shall provide a polypropylene pull cord with 2000 lbs. tensile strength in each empty conduit (indoor and outdoor), except in sleeves and nipples.

15. Telecommunications conduits that protrude through the structural floor shall be installed 1 to 3" above finished floor (AFF).

16. Telecommunications conduits that enter into Telecommunications rooms below the finished ceiling shall terminate a minimum of 4" below ceiling and as close to the wall as possible.

17. Telecommunications conduits that are below grade and enter into a building shall terminate a minimum of 4" above finished floor (AFF) and as close to the wall as possible.

3.6 CONDUIT TERMINATIONS

A. Where conduit bonding is indicated or required in the contract documents, the bushings shall be a grounding type sized for the conduit and ground bonding conductor as manufactured by O-Z/Gedney, Appleton, Thomas & Betts, Burndy, Regal, or approved equal.

B. Conduits with termination fittings shall be threaded for one (1) lock nut on the outside and one (1) lock nut and bushing on the inside of each box.

C. Where conduits terminate in boxes with knockouts, they shall be secured to the boxes with lock nuts and provided with approved screw type tinned iron bushings or fittings with plastic inserts.

D. Where conduits terminate in boxes, fittings, or bodies with threaded openings, they shall be tightly screwed against the shoulder portion of the threaded openings.

E. Conduit terminations to all motors shall be made with flexible metallic conduit (FMC), unless noted otherwise. Final connections to roof exhaust fans, or other exterior motors and motors in damp or wet locations shall be made with liquidtight flexible metallic conduit (LFMC). Motors in hazardous areas, as defined in the NEC, shall be connected using flexible conduit rated for the environment. Flexible conduit shall not exceed 6' in length. Route equipment ground conductors from circuit ground to motor ground terminal through flexible conduit.

F. Rigid polyvinyl chloride conduit (PVC) shall be terminated using fittings and bodies produced by the manufacturer of the conduit, unless noted otherwise. Prepare conduit as per manufacturer's recommendations before joining. All joints shall be solvent welded by applying full even coat of plastic cement to the entire areas that will be joined. Turn the conduit at least a quarter to one half turn in the fitting and let the joint cure for 1-hour minimum or as per the manufacturer's recommendations.

G. All conduit ends shall be sealed with plastic immediately after installation to prevent the entrance of any foreign matter during construction. The seals shall be removed and the conduits blown clear of any and all foreign matter prior to any wires or pull cords being installed.

3.7 UNDERGROUND CONDUIT INSTALLATION

A. Conduit Connections:

1. Conduit joints in a multiple conduit run shall be staggered at least one foot apart.

B. Conduit Bends (Lateral):

1. Conduits shall have long sweep radius elbows instead of standard elbows wherever special bends are indicated and noted on the drawings, or as required by the manufacturer of the equipment or system being served.

2. Telecommunications conduit bend radius shall be six times the diameter for conduits under 2" and ten times the diameter for conduits over 2". Where long cable runs are involved, sidewall pressures may require larger radius bends. Coordinate with Architect/Engineer prior to conduit installation to determine bend radius.

C. Conduit Elbows (vertical):

1. Minimum metal or RTRC elbow radiuses shall be 30 inches for primary conduits (>600V) and 18 inches for secondary conduits (<600V). Increase radius, as required, based on pulling tension calculation requirements.

D. Conduit Placement:

1. Conduit runs shall be pitched a minimum of 4" per 100 feet to drain toward the terminations. Duct runs shall be installed deeper than the minimum wherever required to avoid any conflicts with existing or new piping, tunnels, etc.

2. For parallel runs, use suitable separators and chairs installed not greater than 4' on centers. Band conduit together with suitable banding devices. Securely anchor conduit to prevent movement during concrete placement or backfilling.

3. Where concrete is required, the materials for concreting shall be thoroughly mixed to a minimum f'c = 2500 and immediately placed in the trench around the conduits. No concrete that has been allowed to partially set shall be used.

4. Before the Contractor pulls any cables into the conduit he shall have a mandrel 1/4" smaller than the conduit inside diameter pulled through each conduit and if any concrete or obstructions are found, the Contractor shall remove them and clear the conduit. Spare conduit shall also be cleared of all obstructions.

5. Conduit terminations in manholes, masonry pull boxes, or masonry walls shall be with malleable iron end bell fittings.

6. All spare conduits not terminated in a covered enclosure shall have its terminations plugged as described above.

7. Ductbanks and conduit shall be installed a minimum of 24" below finished grade, unless otherwise noted on the drawings or elsewhere in these specifications.

8. All non-metallic conduit installed underground outside of a slab shall be rigid.

E. Horizontal Directional Drilling:

1. Entire drill path shall be accurately surveyed, with entry and exit stakes placed and coordinated with other contractors. If using a magnetic guidance system, entire drill path shall be surveyed for any surface geo-magnetic variations or anomalies.

2. Any utility locates within 20 feet of the bore path shall have the exact location physically verified by hand digging or vacuum excavation. Restore inspection holes to original condition after verification.

F. Raceway Seal:

1. Where a raceway enters a building or structure, it shall be sealed with a sealing bushing or duct seal to prevent the entry of liquids or gases. Seal must be compatible with conductors and raceway system. Spare or unused raceway shall also be sealed.

2. All telecommunications conduits and innerducts, including those containing cables, shall be plugged at the building and vault with “JackMoon” or equivalent duct seal, capable of withstanding a 10 foot head of water (5 PSI).

3.8 CONDUIT INSTALLATION SCHEDULE

A. In the event the location of conduit installation represents conflicting installation requirements as specified in the following schedule, a clarification shall be obtained from the Architect/Engineer. If This Contractor is unable to obtain a clarification as outlined above, concealed rigid galvanized steel conduit installed per these specifications and the NEC shall be required.

B. The following schedule shall be adhered to unless they constitute a violation of applicable codes or are noted otherwise on the drawings. The installation of RMC conduit will be permitted in place of any and all conduit specified in this schedule.

1. Exposed:
    a. Switchboards, panel feeders, etc.: IMC.
    b. Branch Circuits (lighting, receptacles, controls, etc.): EMT.
    c. Mechanical Equipment Feeders (pumps, AHU's, chillers, etc.): EMT.
    d. Floor Mounted Pump Feeders: EMT with no more than 6’ of PVC coated flexible metal conduit to pump.
    e. Controls: EMT painted blue or dyed blue.
2. Finished Spaces/Concealed: EMT.
3. Wet or Damp Locations: RMC conduit, boxes and fittings, installed and equipped so as to prevent water from entering the conduit system.
4. Corrosive Locations: PVC Coated Rigid Metal conduit, boxes and fittings installed and equipped so as to prevent water from entering the conduit system.
5. Under Slabs on Grade:
    a. Within 5’ from the perimeter of the building: RMC
    b. Within 5’ from the perimeter of the building when passing through the perimeter of the building foundation: RMC.
6. Site Conduits:
    a. Within 5' from the Perimeter of a Building Foundation: RMC.
    b. 5' or Greater from the Perimeter of a Building Foundation: PVC.
    c. Under Roads, Drives, and Vehicle Traveled Ways: Concrete encased PVC with a minimum of 3” concrete cover on all sides of conduit.
7. Hazardous Locations as Defined by the NEC: RMC conduit complete with screwed fittings and conduit seals.

3.9 BOX INSTALLATION SCHEDULE

A. Galvanized steel boxes may be used in:

1. Concealed interior locations above ceilings and in hollow studded partitions.
2. Exposed interior locations in mechanical rooms and in rooms without ceilings; higher than 8’ above the highest platform level.

3. Direct contact with concrete except slab on grade.
4. Recessed in stud wall of kitchens and laundries.

B. Cast boxes shall be used in:

1. Exterior locations.
2. Hazardous locations.
3. Exposed interior locations within 8' of the highest platform level.
4. Direct contact with earth.
5. Direct contact with concrete in slab on grade.
6. Wet locations.
7. Kitchens and laundries when exposed on wall surface.

3.10 COORDINATION OF BOX LOCATIONS

A. Provide electrical boxes as shown on the drawings, and as required for splices, taps, wire pulling, equipment connections, and code compliance.

B. Electrical box locations shown on the Contract Drawings are approximate, unless dimensioned. Verify location of floor boxes and outlets in offices and work areas prior to rough-in.

C. Locate and install boxes to allow access. Avoid interferences with ductwork, piping, structure, equipment, etc. Where installation is inaccessible, provide access doors. Coordinate locations and sizes of required access doors with the Architect/Engineer and General Contractor.

D. Locate and install to maintain headroom and to present a neat appearance.

E. Coordinate locations with Heating Contractor to avoid baseboard radiation cabinets.

3.11 OUTLET BOX INSTALLATION

A. Do not install boxes back-to-back in walls.

1. Provide a minimum horizontal separation of 6 inches between boxes installed on opposite sides of non-rated stud walls. When the minimum separation cannot be maintained, install sound insulation pads on all five sides of the back box in accordance with the manufacturer's instructions.

2. Provide a minimum horizontal separation of 24 inches between boxes installed on opposite sides of fire-rated walls. When the minimum separation cannot be maintained, the box is greater than 16 square inches or the total box area (all trades) per 100 square feet is greater than or equal to 100 square inches, install fire-rated moldable pads to all five sides of the back box to maintain the fire rating of the wall. Install moldable pads in accordance with UL listing for the specific product. Sound insulation pads are not acceptable for use in fire-rated wall applications unless the product carries the necessary fire rating.

B. Install sound insulation pads on all five sides of the back of all boxes in sound-rated wall assemblies. Sound-rated wall assemblies are defined as partition types carrying a Sound Transmission Class (STC) rating.

C. The Contractor shall anchor switch and outlet box to wall construction so that it is flush with the finished masonry, paneling, drywall, plaster, etc. The Contractor shall check the boxes as the finish wall surface is being installed to assure that the box is flush. (Provide plaster rings as necessary.)

D. Mount at heights shown or noted on the drawings or as generally accepted if not specifically noted.

E. Locate boxes in masonry walls to require cutting of masonry unit corner only. Coordinate masonry cutting to achieve neat openings for boxes.

F. Provide knockout closures for unused openings.

G. Support boxes independently of conduit.

H. Use multiple-gang boxes where more than one device are mounted together; do not use sectional boxes. Provide barriers to separate wiring of different voltage systems.

I. Install boxes in walls without damaging wall insulation.

J. Coordinate mounting heights and locations of outlets mounted above counters, benches, backsplashes, and below baseboard radiation.

K. Position outlets to locate luminaires as shown on reflected ceiling drawings.

L. In inaccessible ceiling areas, position outlets and junction boxes within 6 inches of recessed luminaire, to be accessible through luminaire ceiling opening.

M. Provide recessed outlet boxes in finished areas; secure boxes to interior wall and partition studs, accurately positioned to allow for surface finish thickness. Use stamped steel stud bridges for flush outlets in hollow stud wall, and adjustable steel channel fasteners for flush ceiling outlet boxes.

N. Align wall-mounted outlet boxes for switches, thermostats, and similar devices.

O. Provide cast outlet boxes in exterior locations and wet locations, and where exposed rigid or intermediate conduit is used.

3.12 PULL AND JUNCTION BOX INSTALLATION

A. Locate pull boxes and junction boxes above accessible ceilings or in unfinished areas.

B. Support pull and junction boxes independent of conduit.

C. Do not install boxes back-to-back in walls.

1. Provide a minimum horizontal separation of 6 inches between boxes installed on opposite sides of non-rated stud walls. When the minimum separation cannot be maintained, install sound insulation pads on all five sides of the back box in accordance with the manufacturer's instructions.

2. Provide a minimum horizontal separation of 24 inches between boxes installed on opposite sides of fire-rated walls. When the minimum separation cannot be maintained, the box is greater than 16 square inches or the total box area (all trades) per 100 square feet is greater than or equal to 100 square inches, install fire-rated moldable pads to all five sides of the back box to maintain the fire rating of the wall. Install moldable pads in accordance with UL listing for the specific product. Sound insulation pads are not acceptable for use in fire-rated wall applications unless the product carries the necessary fire rating.

D. Install sound insulation pads on all five sides of the back of all boxes in sound-rated wall assemblies. Sound-rated wall assemblies are defined as partition types carrying a Sound Transmission Class (STC) rating.

3.13 EXPOSED BOX INSTALLATION

A. Boxes shall be secured to the building structure with proper size screws, bolts, hanger rods, or structural steel elements.

B. On brick, block and concrete walls or ceilings, exposed boxes shall be supported with no less than two (2) Ackerman-Johnson, Paine, Phillips, or approved equal screw anchors or expansion shields and round head machine screws. Cast boxes shall not be drilled.

C. On steel structures, exposed boxes shall be supported to the steel member by drilling and tapping the member and fastening the boxes by means of round head machine screws.

D. Boxes may be supported on steel members by APPROVED beam clamps if conduit is supported by beam clamps.

E. Boxes shall be fastened to wood structures by means of a minimum of two (2) wood screws adequately large and long to properly support. (Quantity depends on size of box.)

F. Wood, plastic, or fiber plugs shall not be used for fastenings.

G. Explosive devices shall not be used unless specifically allowed.

END OF SECTION

SECTION 26 05 35
SURFACE RACEWAYS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Surface metal raceways
B. Surface non-metallic raceways

1.2 REFERENCES

A. FS W-C-582 - Conduit, Raceway, Metal, and Fitting; Surface

PART 2 - PRODUCTS

2.1 SURFACE METAL RACEWAY

A. Surface Metal Raceway: FS W-C-582; sheet metal channel with fitted cover, suitable for use as a continuous surface metal raceway.

B. Finish: Coordinate paint color with Architect.

C. Fittings: Couplings, elbows, and connectors designed for use with raceway system.

D. Boxes and Extension Rings: Designed for use with raceway systems.

E. Coverplates shall be stainless steel.

F. Normal power receptacles shall be same color as raceway. Coordinate color with Architect.

G. Receptacles and outlets shown on raceway on drawings shall be mounted with overlapping faceplates in the raceway and shall not be mounted in boxes unless specifically noted otherwise.

H. **[WW-1]:** Surface metal raceway, metallic cover, minimum 2” opening, minimum 3 square inch capacity.

1. Approved Manufacturers: Wiremold G3000, Mono-Systems SMS3200, Hubbell HBL3000 Series.

I. **[WW-2]:** Surface metal raceway, metallic cover, minimum 4” opening, power / communication divider, minimum 7.5 square inch capacity.

1. Approved Manufacturers: Wiremold G4000/G4048, Mono-Systems SMS4200, Hubbell HBL4750 Series.

J. **[WW-3]**: Surface metal raceway, metallic cover, minimum 4” opening, power / communication divider, minimum 16.6 square inch capacity.

1. Approved Manufacturers: Wiremold G6000/G4048, Mono-Systems SMS4400, Hubbell HBL6750 Series.

2.2 SURFACE NON-METALLIC RACEWAY

A. Surface Non-Metallic Raceway: Polyvinyl chloride channel with fitted cover; UL listed for power conductors.

B. Length: As shown on the drawings.

C. Finish: Field paint with latex paint; color selected by Architect.

D. Fittings and Accessories: Couplings, elbows, outlet and device boxes, and connectors designed for use with the raceway system.

E. Coverplates shall be same material and finish as raceway.

F. Normal power receptacles shall be same color as raceway. Coordinate color with Architect.

G. Acceptable Manufacturers: Wiremold PN20A Series, Hubbell PW2 Series.

PART 3 - EXECUTION

3.1 INSTALLATION - SURFACE METAL RACEWAY

A. Only install in locations pre-approved by Architect/Engineer.

B. Use flat-head screws to fasten channel to surfaces. Mount plumb and level.

C. Use suitable insulating bushings and inserts at connections to outlets and corner fittings.

D. Maintain grounding continuity between raceway components to provide a continuous grounding path.

E. Fastener: Use clips and straps suitable for the purpose.

F. Field cuts to be clean and straight and use the proper tools as recommended by the system manufacturer to prohibit damage to factory finish or raceway. Joints to be matched so there are no gaps or spaces in the cover. Furnish and install manufacturer's raceway accessories as needed.

G. Provide conduits to technology raceway per drawings or provide a minimum of one (1) 1-1/4" conduit per six feet of assembly (minimum 2) to above ceiling for technology requirements if assembly has technology raceway (Contractor shall provide quantities of conduits that provide maximum capacity to assembly). Provide conduits equally spaced within entire length of assembly.

H. Provide one (1) 3/4" empty conduit per six feet of assembly (minimum 1) to above ceiling for future power needs. Provide conduits equally spaced within entire length of assembly.

3.2 INSTALLATION - SURFACE NON-METALLIC RACEWAY

A. Only install in locations pre-approved by Architect/Engineer.

B. Use flat-head screws to fasten channel to surfaces. Mount plumb and level.

C. Do not locate raceway near heating elements, open flames or surfaces with a probable temperature greater than 150°F.

D. Do not locate raceway where there is a probability of contact with oils, chemicals or moisture.

E. Contractor shall install a bonded ground conductor the entire length of the raceway.

F. Field cuts to be clean and straight and use the proper tools as recommended by the system manufacturer to prohibit damage to factory finish or raceway. Joints to be matched so there are no gaps or spaces in the cover. Furnish and install manufacturer's raceway accessories as needed.

G. Provide conduits to technology raceway per drawings or provide a minimum of one (1) 1-1/4" conduit per six feet of assembly (minimum 2) to above ceiling for technology requirements if assembly has technology raceway (Contractor shall provide quantities of conduits that provide maximum capacity to assembly). Provide conduits equally spaced within entire length of assembly.

H. Provide one (1) 3/4" empty conduit per six feet of assembly (minimum 1) to above ceiling for future power needs. Provide conduits equally spaced within entire length of assembly.

END OF SECTION

SECTION 26 05 36
CABLE TRAYS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Cable trays
B. Cable tray accessories

1.2 QUALITY ASSURANCE

A. NEC Compliance: Comply with NEC as applicable to construction and installation of cable tray and cable channel systems (Article 392, NEC).

B. NFPA Compliance: Comply with NFPA 70B, "Recommended Practice for Electrical Equipment Maintenance" pertaining to installation of cable tray systems.

1.3 REFERENCES

A. ANSI/NFPA 70 – National Electrical Code

B. ASTM A123 – Specification for Zinc (Hot Galvanized) Coatings on Iron and Steel

C. ASTM A510 – Specification for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel

D. ASTM B633 – Specification for Electrodeposited Coatings of Zinc on Iron and Steel

E. NEMA VE 1 – Metallic Cable Tray Systems

F. NEMA VE 2 – Cable Tray Installation

1.4 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 26 05 00.

B. Indicate tray type, dimensions, support points, clamps, hangers, connectors, fittings, expansion joint assemblies, accessories and finishes.

C. Submit manufacturer's installation instructions under provisions of Section 26 05 00.

D. Include cable tray in composite electronic coordination files. Refer to Section 26 05 00 for coordination drawing requirements.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver materials to site in manufacturer's original, unopened containers and packaging.

B. Store materials in a dry area indoors, protecting from damage and in accordance with manufacturer's instructions.

1.6 TESTING AND COMMISSIONING

A. Visually inspect each cable tray ground connection for mechanical continuity.

B. Visually inspect each structural suspension point for specified loading and spacing.

C. Submit notification of testing and results under provisions of Section 26 05 00.

1.7 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 26 05 00.

B. Include cleaning and bolt-tightening procedures.

C. Note grounding point on as-built drawings.

1.8 COORDINATION

A. Coordinate layout and installation of cable trays and suspension system with other construction, including structural members, light fixtures, HVAC equipment, fire suppression systems, and partition assemblies.

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide all cable tray with all fittings and mounting hardware. Install according to NEMA class with 1.5 safety factor.

B. Accessories and Fittings: Manufacturer's standard clamps, hangers, brackets, splice plates, reducer plates, blind ends, barrier strips, connectors, and grounding straps.

C. Refer to manufacturers installation instructions and specific product data below for additional information.

1. Approved Manufacturers: Cooper B-Line Series 35, Cope, Thomas & Betts, Cablofil

2. Manufacturers: Cooper B-Line Channel CC Series, Cope, Thomas & Betts, Cablofil

2.2 WELDED WIRE MESH CABLE TRAYS

A. [CT-#]: Wire mesh type cable tray, 4” loading depth, width indicated on plans. Provide trapeze support with plastic retainer.

1. Approved Manufacturers: B-Line, Mono-Systems, Cope, Cablofil Inc., Hubbell HBT.

B. Tray: Continuous, rigid, welded steel wire mesh cable tray with continuous top wire safe edge with T-weld.

C. Wire mesh shall be welded at all intersections.

D. Material: Carbon steel wire, 0.197” minimum wire diameter, ASTM A510, Grade 1008. Wire shall be welded, formed and surface treated.

E. Finish: Finish shall be applied after welding and bending of mesh. Finish shall be electro-plated zinc galvanizing: ASTM B633, Type I, SC-1.

F. Provide grounding clip for continuous grounding of tray.

G. Accessories: Provide all supporting, hanging, tee, cross, level change, reducing, drop outs, and miscellaneous hardware as required for a complete and functioning installation to manufacturer’s recommendations.

H. Load Span Criteria: Install and support cable management system in accordance with span load criteria of L/240.

2.3 WARNING SIGNS

A. Provide manufacturer's standard, permanent, legible warning label indicating the following:

WARNING! DO NOT USE AS A WALKWAY, LADDER, OR SUPPORT FOR PERSONNEL. TO BE USED ONLY AS MECHANICAL SUPPORT FOR CABLES AND TUBING!

B. Label shall also indicate cable tray NEMA load class. Label shall be a maximum of 10' on center.

C. Cable trays containing conductors rated over 600 volts shall have a label with the wording "DANGER-HIGH VOLTAGE-KEEP AWAY".

D. Cable trays containing service entrance conductors shall be labeled with "CABLE TRAY CONTAINS SERVICE-ENTRANCE CONDUCTORS".

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation: In conformance with NEMA VE 2 requirements and in accordance with manufacturer's instructions.

B. Support cable tray at each connection point, at the end of each run, and at other points to maintain spacing between supports of 8 ft. maximum.

C. Use expansion connectors where indicated in NEMA VE 1.

D. Cut standard straight sections to length in field.

E. Tray shall be electrically continuous from source to termination and shall not change elevation, direction or otherwise expose cables to travel without support.

F. Tray shall be field cut using the manufacturer's approved cutting device and methods. Cutting device shall be an offset blade bolt cutter. The use of standard bolt cutters is strictly prohibited.

G. Bends in tray shall be accomplished by utilizing manufacturer's cutting guides.

H. All splices of tray shall be provided with splice washers, bars or springs as recommended by the manufacturer.

I. Provide bonding continuity between cable tray sections, fittings and conduit terminations in accordance with manufacturer's instructions.

J. Tighten electrical connectors and terminals per manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

K. Remove burrs and sharp edges from cable trays.

L. Seal penetrations through fire and smoke barriers.

M. Install capped sleeves for future cables through firestop sealed cable tray penetrations of fire and smoke barriers as shown on drawings.

N. Install cable trays with sufficient space to permit access for installing cables. Install tray bottom within 18" of access ceiling paneling for ease of access. Adjust mounting height only momentarily for field coordination with other trades and systems as required.

O. Provide separation of cables of different systems, such as power, telecommunications, fire alarm system, security systems and audio or visual systems. Install barriers between power and low voltage cables.

END OF SECTION

SECTION 26 05 53
ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Nameplates and tape labels
B. Wire and cable markers
C. Conduit labeling
D. Conduit color coding
E. Conductor color coding
F. Electrical gear labeling
G. Power distribution equipment labeling
H. Transformer equipment labeling
I. Series rating identification
J. Pole identification

1.2 REFERENCES

A. ANSI C2 – National Electrical Safety Code

B. NFPA 70 – National Electrical Code

C. ANSI A13.1 – Standard for Pipe Identification

D. ANSI Z535.4 – Standard for Product Safety Signs and Labels

PART 2 - PRODUCTS

2.1 ELECTRICAL IDENTIFICATION PRODUCTS

A. Adhesive Marking Labels for Raceway: Pre-printed, flexible, self-adhesive vinyl labels with legend indicating voltage and service (Emergency, Lighting, Power, HVAC, Communications, Control, Fire).

1. Label Size as follows:

a. Raceways: Kroy or Brother labels 1-inch high by 12-inches long. (Minimum)

2. Color: As specified for various systems.

B. Colored Adhesive Marking Tape for banding Raceways, Wires, and Cables: Self-adhesive vinyl tape not less than 3 mils thick by 1 inch to 2 inches in width.

C. Pretensioned Flexible Wraparound Colored Plastic Sleeves for Cable Identification: flexible acrylic bands sized to suit the cable diameter and arranged to stay in place by pre-tensioned gripping action when coiled around the cable.

D. Wire/Cable Designation Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound, cable/conductor markers with preprinted numbers and letter.

E. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking nylon cable ties, 0.18-inch minimum width, 50-lb minimum tensile strength, and suitable for a temperature range from minus 50°F to 350°F. Provide ties in specified colors when used for color coding.

F. Underground Plastic Markers: Bright colored continuously printed plastic ribbon tape of not less than 6 inches wide by 4 mil thick, printed legend indicating type of underground line, manufactured for direct burial service. Tape shall contain a continuous metallic wire to allow location with a metal detector.

G. Aluminum, Wraparound Marker Bands: 1" in width, .014 inch thick aluminum bands with stamped or embossed legend, and fitted with slots or ears for permanently securing around wire or cable jacket or around groups of conductors.

H. Brass or aluminum Tags: 2" by 2" by .05-inch metal tags with stamped legend, punched for fastener.

I. Indoor/Outdoor Number and Letters: Outdoor grade vinyl label, minimum of 3/4" high x 9/16" wide, with acrylic adhesive designed for permanent application in severe indoor and outdoor environments.

2.2 NAMEPLATES AND SIGNS

A. Engraved, Plastic-Laminated Labels, Signs and Instruction Plates: Engraving stock melamine plastic laminate, 1/16-inch minimum thick for signs up to 20 square inches, or 8 inches in length; 1/8 inch thick for larger sizes. Labels shall be punched for mechanical fasteners. Engraving legend shall be as follows:

1. Black letters on white face for normal power.
2. White letters on red face for emergency power.
3. White letters on green face for grounding.
4. Black letter on yellow face for Caution or UPS.

B. Baked–Enamel Signs for interior Use: Preprinted aluminum signs, punched, or drilled for fasteners, with colors, legend, and size required for application. Mounting ¼" grommets in corners.

C. Exterior, Metal-Backed, Butyrate Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with .0396 inch galvanized-steel backing: and with colors, legend, and size required for application. Mounting ¼" grommets in corners.

D. Safety Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145.

E. Fasteners for Plastic-Laminated Signs; Self-tapping stainless steel screws or number 10/32 stainless steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lettering and Graphics: Coordinate names, abbreviations, colors, and other designations used in electrical identification work with corresponding designations specified or indicated. Install numbers, lettering, and colors as required by code.

B. Install identification devices in accordance with manufacturer's written instruction and requirements of NEC.

C. Sequence of Work: Where identification is to be applied to surfaces that require finish, install identification after completion of finish work. All mounting surfaces shall be cleaned and degreased prior to identification installation.

D. Identify Junction, Pull and Connection Boxes: Labeling shall be 3/8-inch Kroy tape or permanent magic marker (color coded), neatly hand printed. In rooms that are painted out, provide labeling on inside of cover.

E. Circuit Identification: Tag or label conductors as follows:

1. Multiple Power or Lighting Circuits in Same Enclosure: Where multiple branch circuits are terminated or spliced in a box or enclosure, label each conductor with source and circuit number.

2. Multiple Control Wiring and Communication/Signal Circuits in Same Enclosure: For control and communications/signal wiring, use wire/cable marking tape at terminations in wiring boxes, troughs, and control cabinets. Use consistent letter/number conductor designations throughout on wire/cable marking tape.

3. Match identification markings with designations used in panelboards shop drawings, Contract Documents, and similar previously established identification schemes for the facility's electrical installations.

F. Apply warning, caution and instruction signs as follows:

1. Install warning, caution or instruction signs where required by NEC, where indicated, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions or explanations are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.

2. Emergency Operating Signs: Install, where required by NEC, where indicated, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect, engraved laminate signs with white legend on red background with minimum 3/8-inch high lettering for emergency instructions on power transfer, load shedding, or other emergency operations.

G. Apply circuit/control/item designation labels of engraved plastic laminate for pushbuttons, pilot lights, alarm/signal components, and similar items, except where labeling is specified elsewhere.

H. Install labels parallel to equipment lines at locations as required and at locations for best convenience of viewing without interference with operation and maintenance of equipment.

I. Install ARC FLASH WARNING signs on all switchboards, panelboards, industrial control panels, and motor control centers. Sign at a minimum shall contain:

J. Underground Electrical Lines: For exterior underground power, control, signal, and communication lines, install continuous underground plastic line marker located directly above line at 6 to 8 inches below grade. Where width of multiple lines installed in a common trench or concrete envelope does not exceed 16 inches overall, use a single marker. Install line marker for underground wiring, both direct-buried cables and cables in raceway.

3.2 SWITCH AND RECEPTACLE COVER PLATES

A. Provide identification on all switch and receptacle cover plates. Identification shall indicate source and circuit number serving the device (i.e. "C1A #24").

B. Identification material to be a clear, 3/8-inch Kroy tape or Brother self-laminating vinyl label with black letters in normal size “Swiss 721 Bold” font. Letter and number size to 3/16-inch high. Embossed Dymo-Tape labels are not acceptable. Permanently affix identification label to cover plates, centered above the receptacle openings.

3.3 CONDUIT AND EXPOSED CABLE LABELING

A. Conduit Identification: Pre-printed, flexible, self-adhesive vinyl labels with legend at 20 foot intervals to identify all conduits run exposed or located above accessible ceilings. Conduits located above non-accessible ceiling or in floors and walls shall be labeled within 3 feet of becoming accessible. Labels for multiple conduits shall be aligned. Use the following colors

1. 600 Volts and Below Normal: White letters on black background indicating feeder identification and voltage.
2. 600 Volt and Below Emergency: White or black letters on red background indicating feeder identification and voltage.
3. Fire Alarm: Red letter on white background indicating “FIRE ALARM”.
4. Temperature Control: White or black letters on blue background.
5. Grounding: White letters on green background indicating “GROUND” and equipment and designation.
6. Security System: Blue letters on yellow background indicating "Security".
7. Telephone System: Green letters on yellow background indicating "Telephone".

B. Blank conduit ends or outlet boxes for future extension of system shall have permanent identification marker indicating purpose of conduit or box and where the raceway originated.

3.4 BOX LABELING

A. All junction, pull, and connection boxes shall be identified as follows:

1. For power and lighting circuits, indicate system voltage and identity of contained circuits (“120V, 1LA1-3,5,7”).
2. For other wiring, indicate system type and description of wiring (“FIRE ALARM NAC #1”).

B. Box covers shall be painted to correspond with system type as follows:

1. Box color to match conduit color indicated below.

3.5 CONDUIT COLOR CODING SCHEDULE

A. Provide color coded conduit as indicated below. Conduit shall be colored by the manufacturer:

1. Fire Alarm System: Red.
2. Normal Power Distribution System 277V/480V: Silver. Labeled as “277/480Y”
3. Normal Power Distribution System 120V/208V: Silver. Labeled as “120/208Y”
4. Emergency Power Distribution System: Green, Labeled per Voltage used.
5. Optional Standby: Blue, Labeled per Voltage used.
6. DC Voltage (Solar etc.): Orange, labeled as “600VDC” or per system rating.
7. Temperature Controls, Motor Control and Other Control or Building Automation Systems: White. Labeled as “BAS”

8. Communication (CAT6, Fiber, Access System, Radio, etc.): Purple. Labeled “COM”, “FIBER”, or as directed by owner.
9. Security System: Yellow.
10. Ground: Green.

B. Blank conduit ends or outlet boxes for future extension of system shall have permanent identification marker indicating purpose of conduit or box and where the raceway originated.

C. This Contractor shall furnish and install framed 8" x 10" charts of the color coded identification scheme used for the electrical system in all electrical rooms and next to the main fire alarm panel.

3.6 CONDUIT COLOR CODING SCHEDULE

A. Identify Raceways with Color Banding: Band exposed or accessible raceways, cables, and bare conductors of the following systems for identification. Bands shall be pretensioned, snap-around colored plastic sleeves, colored adhesive marking tape, or a combination of the two. Make each color band 2 inches wide, completely encircling conduit, and place adjacent bands of two-color markings in contact, side by side. Install bands at changes in direction, at penetrations of walls and floors, at each junction box and at 20-foot maximum intervals in straight runs. Apply the following colors:

B. System Conduit Color:

1. Primary Distribution System: Silver.
2. Normal 480Y/277 Volt Distribution System: Orange.
3. Normal 208Y/120 Volt, Distribution System: White.
4. Fire Alarm System: Red.
5. Motor and Other Control Systems: Black.
6. Telephone System: Green/Yellow banding.
7. Clock, Sound & Intercom: Blue.
8. Emergency 480Y/277 Volt Distribution System: Orange/Yellow band.
9. Emergency 208Y/120 Volt Distribution System: White/Yellow band.
10. Nurse Call: Green.
11. Security System: Blue/Yellow band.
12. Ground: Green.

C. Where conduit leaves a switchboard or panelboard, identification shall be installed on each conduit indicating load served.

D. Where conduit is above an accessible ceiling, each electrical system shall be color coded and identified.

E. Identification of emergency conduit shall be by means of spray painted bands on maximum of 10'-0" centers.

F. Blank conduit ends or outlet boxes for future extension of system shall have permanent identification marker indicating purpose of conduit or box and where the raceway originated.

G. This Contractor shall furnish and install framed 8" x 10" charts of the color coded identification scheme used for the electrical system in all electrical rooms and next to the main fire alarm panel.

3.7 CONDUCTOR COLOR CODING

A. Color coding shall be applied at all panels, switches, junction boxes, pull boxes, vaults, manholes etc., where the wires and cables are visible and terminations are made. The same color coding shall be used throughout the entire electrical system, therefore maintaining proper phasing throughout the entire project.

B. Where more than one nominal voltage system exists in a building or facility, the identification of color coding used in the panelboard or equipment shall be permanently posted on the interior of the door or cover.

C. All wires and cables, 6 AWG or larger, used in motor circuits, main feeders, sub-main feeders and branch circuits, shall be coded by the application of plastic tape. The tape shall be 3-M, Plymouth or Permacel, in colors specified below. The tape shall be applied at each conductor termination with two 1-inch tape bands at 6-inch centers. Contractor option to use colored cabling in lieu of the tape at each end for conductor 6 AWG to 500 KCM.

D. Wire and cables smaller than 6 AWG shall be color coded by the manufacturer.

E. Colored cable ties shall be applied in groups of three ties of specified color to each conductor at each terminal or splice point starting 3 inches from the termination and spaced at 3- inches centers. Tighten to a snug fit, and cut off excess length.

F. Where more than one nominal voltage system exists in a building or facility, each ungrounded conductor of a multi-wire branch circuit, where accessible, shall be identified by phase and system.

G. Conductors shall be color coded as follows:

1. 120/240 Volt, 3-Wire:

   a. A-Phase – Black
   b. B-Phase – Red
   c. Neutral – White
   d. Ground Bond – Green

2. 208Y/120 Volt, 4-Wire:

   a. A-Phase – Black
   b. B-Phase – Red
   c. C-Phase – Blue
   d. Neutral – White
   e. Ground Bond – Green

3. 480Y/277 Volt, 4-Wire:

   a. A-Phase – Brown
   b. B-Phase – Orange
   c. C-Phase – Yellow
   d. Neutral – Gray
   e. Ground Bond – Green

3.8 ELECTRICAL GEAR LABELING

A. Exterior electrical gear shall be identified with vinyl label names and numbers to be visible on the exterior of the gear. The labels shall correspond to the 1-line nomenclature and identify each cubicle of multi-section gear.

B. Arc Energy Reduction Label:

1. Provide an engraved plastic laminate label centered at the top of each vertical section of the electrical gear indicating the following when applicable.

   a. Label: “This equipment is designed with a [system listed below]”.

   b. Applicable Systems:

      1) Zone-selective interlocking system for selective coordination and arc energy reduction

2) Differential relaying system for selective coordination and arc energy reduction

3) Arc energy reducing maintenance switch

4) Energy reducing active arc flash mitigation system

3.9 CONTROL EQUIPMENT IDENTIFICATION

A. Provide identification on the front of all control equipment, such as disconnect switches, starters, VFDs, contactors, motor control centers, etc. Nameplate text shall be a minimum of 1/4" high.

B. Labeling shall include:

1. Equipment type and contract documents designation of equipment being served.
2. Location of equipment being served if it is not located within sight.
3. Voltage and phase of circuit(s).
4. Panel and circuit number(s) serving the equipment.
5. Method of automatic control, if included ("AUTO CONTROL BY FCMS").

EXHAUST FAN EF-1 ("LOCATED ON ROOF")
480V, 3-PHASE
FED FROM "1HA1-1"

3.10 POWER DISTRIBUTION EQUIPMENT IDENTIFICATION

A. Provide identification on the front of all power distribution equipment, such as panelboards, switchboards, etc. The identification material shall be engraved plastic-laminated labels. Text shall be a minimum of 1/4" high, Swiss 721 Bold.

B. Labeling shall include:

1. Equipment type and contract documents designation of equipment.
2. Voltage of the equipment.
3. Name of the upstream equipment and location of the upstream equipment if it is not located within sight.
4. Rating and type of the overcurrent protection device serving the equipment if it is not located within sight ("FED BY 400A/3P BREAKER").

DISTRIBUTION PANEL DP-H1
480Y/277V
FED FROM SWITCHBOARD "SB-1" (LOCATED IN MAIN ELECTRIC ROOM)

C. A separate nameplate for the service entrance equipment shall be labeled with the MAXIMUM AVAILABLE FAULT CURRENT and DATE of calculation given on the one-line diagram.

D. Distribution panelboards and switchboards shall have each overcurrent protection device identified with name and location of the load being served ("AHU-1 LOCATED IN PENTHOUSE 1").

E. Branch panelboards shall be provided with typed panel schedules upon completion of the project. Existing panelboards shall have their existing panel schedules typed, with all circuit changes, additions or deletions also typed on the panel schedules. A copy of all panel schedules for the project shall be turned over as part of the O&M Manuals. Refer to Section 26 05 00 for other requirements.

3.11 POLE IDENTIFICATION

A. Lighting poles shall be individually identified with a unique number, for maintenance purposes. Apply the vinyl label number above the hand hole cover or 24" above grade.

END OF SECTION

SECTION 26 05 73
POWER SYSTEM STUDY

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Low voltage distribution system power study.
B. Short-circuit analysis and report.
C. Selective coordination analysis and report.
D. Arc-flash hazard analysis and report.

1.2 SUBMITTALS

A. Analyses shall be performed by an agent authorized by the manufacturer of equipment specified in the related specification sections and shall bear the seal/signature of the licensed Professional Engineer who performed the analysis.

B. The input for the power system study shall be based on the contract documents, with estimated conductor lengths provided by the Electrical Contractor. IMEG will provide a preliminary Power Tools for Windows project file for information, if requested.

C. Documentation of the analyses shall be submitted in a bound booklet format and shall accompany the shop drawing submittals for equipment provided under the related work specification sections. These shop drawings will not be reviewed without this documentation. Submit a sample arc-flash hazard label for Owner review and approval prior to printing.

D. Power system study project model shall be submitted on electronic media for review and the Owner's operating and maintenance records.

1.3 SCOPE

A. Provide a power system study of the electrical system shown on the plans. The study shall include arc-fault analysis, selective coordination analysis and arc flash hazard analysis.

B. Contractor is required to provide a fully coordinated system for the essential electrical system and the associated normal side of each transfer switch and all other locations indicated on the one line diagram. Contractor shall provide overcurrent protective devices with the appropriate models, frame sizes, trip units, etc. as required to provide a selectively coordinated system.

PART 2 - PRODUCTS

2.1 Power systems study shall be completed in Power Tools for Windows **(PTW) 7.0** or later version or pre-approved equivalent program**.**

PART 3 - EXECUTION

3.1 SHORT-CIRCUIT ANALYSIS

A. Provide a complete short-circuit analysis from the utility service to and including the entire building distribution as shown on the drawings.

B. Analysis shall include the entire distribution system from the point of connection to the utility power source to the distribution panels and branch circuit panelboards.

C. Documentation shall be made in one-line diagram form showing the magnitude and location of each calculated fault. Fault current calculations shall be made at the main bus of each switchboard, distribution panel, and branch circuit panel. A summary of the fault currents available shall also be submitted.

3.2 SELECTIVE COORDINATION ANALYSIS

A. Provide a complete selective coordination analysis, comparing time/current curves of the protective devices to be installed to assure complete selectivity between main and downstream devices for code-required branches and branches identified on one-line drawings. Overcurrent protective devices serving the essential electrical system shall selectively coordinate for the period of time that a fault's duration extends beyond 0.01 second.

B. The analysis shall include primary protective device, secondary main switchboard device(s), switchboard branch feeder devices, generator breaker, distribution panel, panelboard main devices, and branch feeder devices.

C. The coordination plots provided shall indicate graphically the coordination proposed for the system on full-size log forms and shall define the types of protective devices selected, together with proposed time dial and pickup settings required. The plots shall include titles, representative one-line diagrams, legend, complete parameters for transformer(s), and complete operating bands for circuit breaker trip devices, fuses, etc.

1. The long-time region of the coordination plots shall designate the pickups required for the circuit breakers.

2. The short-time region shall indicate the magnetizing in-rush and ASA-withstand-transformer parameter, the circuit breaker, short-time and instantaneous trip devices, fuse-manufacturing tolerance bands, significant symmetrical fault currents, etc.

3. Include zone selective interlocking, differential relaying, and other selective coordination technology in the study when required by other specification sections.

4. The protective device characteristics or operating bands shall be suitably indicated to reflect the actual symmetrical fault currents sensed by the device.

5. The drawings and specifications indicate the general requirements for motors, motor-starting equipment, and medium-voltage and low-voltage equipment, but additional specific requirements of equipment furnished shall be determined in accordance with the results of the coordination study.

    a. The study shall include verification of equipment ratings and settings. The Contractor shall keep the study up-to-date with any project changes which affect the study and submit the revised study for review. A final electronic copy shall be submitted with the record drawings.

D. Provide summary table of adjustable overcurrent protective devices settings for the operating and maintenance manual.

3.3 ARC FLASH HAZARD ANALYSIS

A. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2004, Annex D.

B. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, unit substations, motor-control centers, panelboards, busway, and splitters) where work could be performed on energized parts.

C. Safe working distances shall be based on the calculated arc flash boundary considering an incident energy of 1.2 cal/cm^2.

D. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit analysis and coordination study models. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations

E. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared, and the greatest incident energy must be uniquely reported for each equipment location. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum and will assume a minimum motor contribution (all motors off). Conversely, the maximum calculation will assume a maximum contribution from the utility and will assume the maximum amount of motors to be operating. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable.

F. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators should be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond 3 to 5 cycles.

2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to 3 per unit after 10 cycles).

G. For each equipment location with a separately enclosed main device (where there is adequate separation between the line side terminals of the main protective device and the work location), calculations for incident energy and flash protection boundary shall include both the line and load side of the main breaker.

H. Include Arc Energy Reduction (AER) analysis in the study when required by other specification sections.

I. When performing incident energy calculations on the line side of a main breaker (as required per the above), the line side and load side contributions must be included in the fault calculation.

J. Mis-coordination should be checked among all devices within the branch containing the immediate protective device upstream of the calculation location, and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.

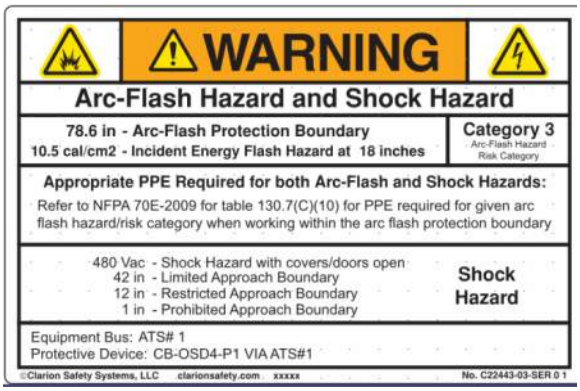
K. Arc flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584-2002 section.

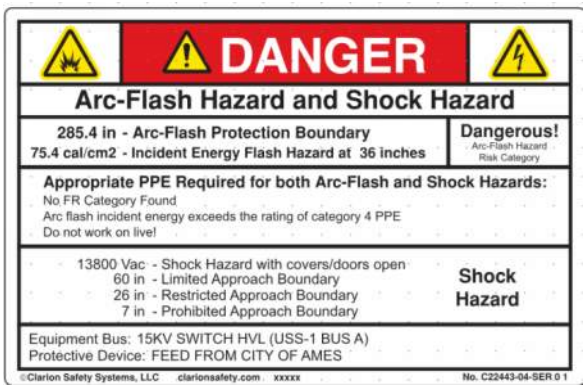
L. Where it is not physically possible to move outside the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.

M. Create and install NFPA 70E compliant labels describing the arc flash hazard level at all switchboards, panelboards, and other locations in the electrical distribution system where work could be performed on energized parts.

N. The label shall include the incident energy calculated in the analysis and the hazard category or appropriate personal protective equipment (PPE) required to perform maintenance on the system when energized. Labels shall be vinyl or laminated, with a self-adhesive backing.

O. Examples showing the minimum required information follow:





P. A list of all hazard categories and the corresponding PPE requirements shall be posted in the main electric room, engineering office, or other location. The list shall be plastic laminate or typewritten and housed in a plastic frame.

3.4 ADJUSTMENTS

A. Manufacturer's authorized representative or Contractor shall set all adjustable protective devices to values indicated in the approved coordination study.

B. Wherever the arc flash incident energy exceeds Arc Flash Category 2 (i.e. > 8 cal/cm^2), provide options for adjusting breaker trip times, if possible, to reduce energies to Category 2 or below.

3.5 TRAINING

A. Provide four hours of Owner training to explain the implications of arc-flash requirements and work permit procedure.

END OF SECTION

SECTION 26 09 33
LIGHTING CONTROL SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Line voltage standalone lighting controls
B. Emergency transfer devices
C. Time switches

1.2 RELATED WORK

A. Section 01 91 00 - Commissioning
B. Section 23 09 00 - Facility Management Control System (FMCS)
C. Section 26 51 00 - Lighting

1.3 QUALITY ASSURANCE

A. Manufacturers shall be regularly engaged in the manufacture of lighting control equipment and ancillary equipment, of types and capacities required, whose products have been in satisfactory use in similar service for not less than five (5) years.

B. All components and assemblies are to be factory pre-tested prior to delivery and installation.

C. Comply with NEC as applicable to electrical wiring work.

D. Comply with applicable portions of NEMA standards pertaining to types of electrical equipment and enclosures.

E. Panels and accessory devices are to be UL listed under UL 916 Energy Management Equipment. Panels and accessories used for control of life safety and critical branch circuits shall be listed under UL 924 Emergency Lighting and Power Equipment.

F. All assemblies are to be in compliance with FCC emissions standards specified in Part 15 Subpart J for Class A applications.

1.4 REFERENCES

A. FCC Rules and Regulations, Part 15, Subpart J - Radio Frequency Interference
B. FS W S 896 Switch, Toggle
C. International Energy Conservation Code (IECC)
D. NEMA WD 1 - General Color Requirements for Wiring Devices
E. NEMA WD 7 - Occupancy Motion Sensors
F. NFPA 70 - National Electrical Code (NEC)
G. UL Standard 916 Energy Management Equipment
H. UL 924 - Emergency Lighting and Power Equipment
I. UL 1472 – Solid-State Dimming Controls

1.5 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

B. Submit a comprehensive package including devices, hardware, software, product specification, finishes, dimensions, installation instructions, warranty, system software requirements.

C. Provide floor plan showing location, orientation, and coverage area of each control device, sensor, and controller/interface. For areas requiring multiple sensor devices for appropriate coverage, submit specific manufacturer-approved sensor layout as an overlay directly on the project drawings, either in print or approved electronic form.

D. Submit project specific control wiring diagrams showing all equipment, line voltage, and control wiring requirements for all components including, but not limited to, dimmers, relays, low voltage switches, and occupancy sensors.

1.6 EXTRA STOCK

A. Provide extra stock under provisions of Section 26 05 00.

B. Sensors, Controls, Power Supplies, and Relays: Five (5) percent of quantity installed. Minimum of two (2) of each configuration and type.

1.7 PROJECT RECORD DOCUMENTS

A. Submit project record documents under provisions of Section 26 05 00.

B. Accurately record location of all controls and devices. Include description of switching sequences and circuiting arrangements.

1.8 OPERATION AND MAINTENANCE DATA

A. Submit emergency, operation, and maintenance data under provisions of Section 26 05 00. Data shall also include the following:

1. Schedule for routine maintenance, inspection, and calibration of all lighting control devices and system components. Recommended schedule for inspection and recalibration of sensors.

2. Replacement part numbers for all system components.

B. Identify installed location and labeling for each luminaire controlled by automated lighting controls.

1.9 SYSTEM DESCRIPTION

A. Performance Statement: This specification section and the accompanying lighting design documents describe the minimum material quality, required features, and operational requirements of the lighting control system (LCS). These documents do not convey every wire that must be installed and every equipment connection that must be made. Based on the performance required of the system, as presented in these documents, the Contractor and system manufacturer/vendor are solely responsible for determining all equipment, wiring, and programming required for a complete and operational system.

B. The following control types and features are acceptable. Acceptable control locations are shown on the drawings.

1. Line Voltage Control: Control equipment consists of traditional line voltage wiring devices and equipment such as switches, dimmers and combination occupancy/vacancy sensor switches, etc.

1.10 COMMISSIONING

A. Commissioning of a system or systems specified in this section is part of the construction process. Documentation and testing of these systems, as well as training of the Owner's operation and maintenance personnel, is required in cooperation with the Owner's Representative and the Commissioning Agent. Project closeout is dependent on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Division 1 for detailed commissioning requirements.

B. The Contractor shall notify the Commissioning Agent, Architect/Engineer and Owner's Representative ten (10) working days prior to scheduled commissioning date.

C. The commissioning process requires meeting attendance. Refer to Division 1 for meeting requirements.

D. The system shall be functionally tested by a factory-authorized engineer and comply with the Sequence of Operation. All loads shall be tested live for continuity and freedom from defects, and all control wiring shall be tested for continuity and connections prior to energizing the system.

1.11 WARRANTY

A. Manufacturer shall warrant products under normal use and service to be free from defects in materials and workmanship for a period of two (2) years from date of commissioning.

B. Occupancy, vacancy, daylight sensors and controls shall have a five (5) year warranty from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LIGHTING CONTROLS

A. All items of material having a similar function (e.g., switches, dimmers, sensors, contactors, relays, etc.) shall be of the same manufacturer, unless specifically stated otherwise on drawings or elsewhere in the specifications.

B. Color of lighting controls and sensors shall match the receptacle wiring devices specified in the space.

C. The functions described in the lighting sequence of operation shall dictate the actual lighting control device required to accomplish the functions described for the space.

2.2 DEVICE COLOR

A. All switch, lighting controls, and coverplate colors shall be the same as wiring devices, unless indicated otherwise.

2.3 COVERPLATES

A. All switches and lighting controls shall be complete with coverplates that match material and color of the wiring device coverplates in the space.

B. Where several devices are ganged together, the coverplate shall be of the ganged style for the number of devices used.

C. Install nameplate identification as indicated in Section 26 05 53.

D. Plate-securing screws shall be metal with head color matching the wall plate finish.

2.4 WALL SWITCHES

A. Refer to Electrical Symbols List for device type.

B. **[SW-1P]**: Single Pole Switch:

1. Single throw, 120/277 volt, 20 amp maintained contact. Toggle handle, side and back wired.

2. Approved Manufacturers: Hubbell HBL1221, Leviton 1221-2, Pass & Seymour PS20AC1, Cooper AH1221.

C. **[SW-1P-ADJ]**: Local Timer Switch:

1. User adjustable timeout, 120/277 volt, 800/1200 watt rating. No minimum load requirement. Flashes lights one minute before timeout.

2. Approved Manufacturers: Watt Stopper TS-400, Hubbell Automation TD200.

D. **[SW-1P-K]**: Key Lock Single Pole Switch:

1. Single throw, 120/277 volt, 20 amp maintained contact. Side and back wired. Provide key to Owner.

2. Approved Manufacturers: Hubbell HBL1221L, Leviton 1221-2L, Pass & Seymour PS20AC1-L.

E. **[SW-1P-M]**: Momentary Contact Single Pole Switch:

1. 120/277 volt, 20 amp. Three position, two circuit. Center off toggle spring return handle.

2. Approved Manufacturers: Hubbell HBL1557, Leviton 1257, Pass & Seymour 1251, Cooper 1995.

F. **[SW-1P-PL]**: Red Pilot Light Single Pole Switch:

1. 120 volt maintained contact. Toggle handle. Pilot light on when contact closed (switch on). Side and back wired.

2. Approved Manufacturers: Hubbell HBL1221PL, Leviton 1221-PLR, Pass & Seymour PS20AC1-RPL, Cooper AH1221PL.

G. **[SW-1P-WP]**: Weatherproof Single Pole Switch:

1. Single throw, 120/277 volt, 20 amp maintained contact. Toggle handle, side and back wired. Provide with weatherproof coverplate.

2. Approved Manufacturers: Hubbell1221/HBL1795, Leviton 1221-2, Taymac MM180, Pass & Seymour PS20AC1/CA1-GL, Cooper 2221.

H. **[SW-2P]**: Two Pole Switch:

1. Single throw, 120/277 volt, 20 amp maintained contact. Toggle handle, side and back wired.

2. Approved Manufacturers: Hubbell HBL 1222, Leviton 1222-2, Pass & Seymour PS20AC2, Cooper 2222.

I. **[SW-2P-K]**: Key Lock Two Pole Switch:

1. Single throw, 120/277 volt, 20 amp maintained contact. Side and back wired. Provide key to Owner.

2. Approved Manufacturers: Hubbell HBL1222L, Leviton 1222-2L, Pass & Seymour PS20AC2-L.

J. **[SW-3W]**: Three-way Switch:

1. 120/277 volt, 20 amp. Toggle handle, side and back wired.

2. Approved Manufacturers: Hubbell 1223, Leviton 1223-2, Pass & Seymour PS20AC3, Cooper AH1223.

K. **[SW-3W-K]**: Key Lock Three Way Switch:

1. Single throw, 120/277 volt, 20 amp maintained contact. Side and back wired. Provide key to Owner.

2. Approved Manufacturers: Hubbell HBL1223L, Leviton 1223-2L, Pass & Seymour PS20AC3-L.

L. **[SW-4W]**: Four-way Switch:

1. 120/277 volt, 20 amp. Toggle handle, side and back wired.

2. Approved Manufacturers: Hubbell 1224, Leviton 1224-2, Pass & Seymour PS20AC4, Cooper AH1224.

M. **[SW-4W-K]**: Key Lock Four Way Switch:

1. Single throw, 120/277 volt, 20 amp maintained contact. Side and back wired. Provide key to Owner.

2. Approved Manufacturers: Hubbell HBL1224L, Leviton 1224-2L, Pass & Seymour PS20AC4-L, Cooper AH11224L.

N. **[SW-A-TPCO]**: Three Position-Center Off Switch:

1. 120/277 volt, 20 amp, 2 pole maintained contact. Toggle handle, side and back wired.

2. Approved Manufacturers: Hubbell HBL1386, Leviton 1286, Pass & Seymour 1226, Cooper 2226.

2.5 WALL DIMMERS

A. UL listed with integral air-gap switch for on/off control.

B. Integral EMI/RFI suppression.

C. Non-viewable heat sink.

D. Dimmer compatibility and wiring with the load being controlled shall be verified by Contractor prior to purchase and installation.

E. Dimmer to match device color.

F. **[SW-D-IN]**: Incandescent Style Dimmer:

1. 120 volt, linear slider operator with positive off. 16 amp maximum capacity.

2. Approved Manufacturers: Lutron, Lightolier.

G. **[SW-D-LED]**: LED Electronic Driver Dimmer:

1. 120 volt, decora style linear slider operator with positive off. Color to match adjacent devices. Luminaire manufacturer shall list compatible dimmer manufacturers and models. 0-10V dimmers shall comply with IEC 60629 Annex E.

2. Approved Manufacturers: Compatible with provided LED driver.

H. **[SW-D3-LED]**: LED Electronic Driver Three-Way Dimmer:

1. 120 volt, decora style linear slider operator with positive off. Color to match adjacent devices. Luminaire manufacturer shall list compatible dimmer manufacturers and models. 0-10V dimmers shall comply with IEC 60929 Annex E.

2. Approved Manufacturers: Compatible with provided LED driver.

I. [**SW-OD]**: Wall 0-10V Dimmer / Occupancy sensor:

1. Wall switch with manual on/auto off. 120VAC load rating of 0-800 W for electronic ballast, LED. 277VAC load rating of 0-1,800 W for electronic ballast, LED. adjustable OFF delay. 0-10V dimming with up to 30ma sink. Automatic ON/OFF, manual ON/automatic OFF, or occupancy on to predetermined dimming level go to last dimming setting upon occupancy.

2. Approved Manufacturers: Sensor Switch WSX D Series

J. **[SW-D-LED-M]**: LED Electronic Driver Dimmer with Momentary Contact Switch:

1. 120 volt, decora style linear slider operator with positive off. Color to match adjacent devices. Luminaire manufacturer shall list compatible dimmer manufacturers and models. 0-10V dimmers shall comply with IEC 60629 Annex E. Momentary toggle button or center off toggle spring return handle.

K. **[SW-D-IN-M]**: Incandescent Style Dimmer with Momentary Contact Switch:

1. 120 volt, linear slider operator with positive off. 16 amp maximum capacity. Momentary toggle button or center off toggle spring return handle.

2. Approved Manufacturers: Lutron, Lightolier.

L.

2.6 LOCAL DAYLIGHTING CONTROLS

A. Standalone Interior Photo Sensors:

1. **[SW-LS]**: Daylight Level Sensor - On/Off Control - One Zone:

a. On/Off control. Range of 10-200 FC. Adjustable deadband prevents cycling. Adjustable time delay.

b. Approved Manufacturers: Watt Stopper LS-102, Sensor Switch CM-PC, Hubbell Automation DLCPC Series, Greengate PPS-4.

2. **[SW-LS-3Z]**: Daylight Level Sensor and Controller - On/Off Control - Three Zones:

a. On/off control of up to three 10-amp zones. Range of 10 to 200 FC. Adjustable deadband prevents cycling. Adjustable time delay.

b. Approved Manufacturers: Watt Stopper LCO-203/LS-290C, Hubbell Automation LUXSTATOCM/LUXSTATLS, LC&D Micro GR/2404 iDH/Pcell, Sensor Switch N-CMPC.

3. Sensor shall detect changes in ambient light level and provide triggering of lighting groups in area based on sequence of operation.

4. Sensor shall be configurable via DIP switches at device or via handheld wireless remote programming unit. Settings shall include:

   a. Ambient sensitivity range between 1 and 1,000 foot-candles.
   b. Time delay of 5 to 300 seconds.
   c. Trigger setpoints with deadband adjustment.

5. Sensor shall provide on/off setpoints in quantity as specified on drawings and as shown in the sequence of operation.

6. Sensor shall be ceiling- or wall-mounted for range and viewing angle meeting application requirements as outlined in the sequence of operation.

7. Output signal from sensor shall be linear with light level.

B. **[SW-LS-PC]**: Standalone Exterior Photo Sensors:

1. Sensor shall be within a weatherproof enclosure, with design operation in temperatures of -30°F to +130°F. Sensor shall have threaded stem for box mounting, with knuckle to permit aiming of receptor after installation. Sensor shall be mounted facing north.

2. Sensor shall contain an integral switching contactor rated for 277-volt operation, with loads of up to 1,800 VA. Contacts shall be configured for zero-crossing closure to provide 100,000 cycle minimum operation.

3. Sensor shall detect changes in daylight levels to provide triggering of exterior lighting equipment based on the sequence of operation.

4. Sensor shall be field configurable at the device or via handheld wireless remote controller. Configurable settings shall include:

   a. Ambient sensitivity range of 5 to 1,500 foot-candles.
   b. Adjustable setpoint.
   c. Deadband adjustment by percentage of setpoint.
   d. Time delay of up to five minutes.

5. Sensor shall be equipped with a lens cover that can be applied for system testing during daylight conditions.

6. Approved Manufacturers: Paragon, Tork, Intermatic.

2.7 INDOOR OCCUPANCY AND VACANCY SENSORS

A. General Description: Wall- or ceiling-mounting, solid-state units with a separate power supply/relay unit.

1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied, with a time delay for turning lights off, adjustable over a minimum range of 1 to 30 minutes. Vacancy sensors require a manual switch operation to turn lights on and off, with a time delay for turning lights off when unoccupied.

2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.

3. Relay Unit: Dry contacts rated for 20 A ballast load at 120 and 277 VAC, for 13 amp tungsten at 120 VAC, and for 1 hp at 120 VAC. Power supply to sensor shall be 24 V dc, 150-mA, Class 2 power source as defined by NFPA 70.

4. Mounting:

a. Sensor: Suitable for mounting in any position on a standard outlet box.

b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure. Mount relay above accessible ceiling near entry door to room or area.

c. Time Delay and Sensitivity Adjustments: Recessed and concealed.

5. Indicator: LED to show when motion is being detected during testing and normal operation of the sensor.

6. Bypass Switch: Override the on function in case of sensor failure.

7. Power Supply and Slave Packs: Provide as required for sensor quantity and switching scheme. Mount to standard 1/2" knockout on electrical box above accessible ceiling near entry door to room or area. Sensor power shall be from emergency circuit if emergency lighting is in the area.

8. Detection Coverage (Room): Detect occupancy anywhere in an area based on hand motion.

9. Detection Coverage (Corridor): Detect occupancy based on a half-step motion.

10. Warranty: Five (5) year warranty.

B. Dual-Technology Type: Detect occupancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Particular technology or combination of technologies that controls on and off functions shall be selectable in the field by operating controls on unit.

1. **[SW-VS-D] or [SW-OC-D]**: 360 Degree Coverage Pattern:

a. Frequency greater than 40 KHz. Dual sensing verifications (requires both technologies to activate), either technology maintains on status. Integrated ambient light level sensor (2 to 200 FC range), adjustable sensitivity and time delay, integrated isolated relay contact. Sensor shall control all circuits in area, unless noted otherwise. Initial settings: ambient sensor 40 FC.

b. Approved Manufacturers: Watt Stopper DT 300 Series, Hubbell OMNI-DT2000 or ATD2000C, Greengate OAC-DT, Leviton OSC##-MOW.

2. **[SW-VS-D-W] or [SW-OC-D-W]**: Wall Mounted on Adjustable Swivel Mount:

a. Wall or ceiling sensor with adjustable settings to allow manual on/auto off or auto on/auto off. Integrated ambient light level sensor (2 to 100 FC range).

b. Approved Manufacturers: Watt Stopper DT-200 Series, Hubbell LODTRP, Leviton OSM12--M series.

3. **[SW-O]**: Wall Switch:

a. Wall switch with manual on/auto off. 120/277 VAC load rating of 0-800 W for ballast, LED or tungsten. 5-, 15-, 30-minute adjustable OFF delay. Coverage of minor motion in 12' x 15' pattern.

b. Approved Manufacturers: Watt Stopper DW-100 Series, Hubbell LHMTS, Leviton OSSMT series.

4. **[SW-O2]**: Wall Switch:

a. Multi-relay wall switch with manual on/auto off for two separate loads. 120/277 VAC load relay rating of 0-800 W for ballast, LED or tungsten. 5-, 15-, 30-minute adjustable OFF delay. Coverage of minor motion in 12' x 15' pattern.

b. Approved Manufacturers: Watt Stopper DW-200 Series, Hubbell LHMTD, Leviton OSSMD series.

5. Sensitivity Adjustment: Separate for each sensing technology.

6. Detection Coverage:

a. Task Areas: Detect occupancy anywhere in an area based on hand motion.

b. Circulation Areas: Detect occupancy anywhere in an area based upon half-step walking motion.

C. Mask sensors where necessary to prevent nuisance switching from adjacent areas.

D. PIR Type: Detect occupancy by sensing a combination of heat and movement in area of coverage.

1. **[SW-OC-P-HA]**: High Bay - Aisle Coverage Pattern:

a. 20' to 40' mounting height. Minimum 1.3:1 walking motion coverage pattern to height ratio. Adjustable sensitivity and time delay, integral isolated relay contact. Sensor shall control all luminaires in area. Initial settings: Time delay 10 minutes.

b. Approved Manufacturers: Watt Stopper HB-300 Series, Hubbell FHB 140 or HMHB series, Leviton OSFHU, Greengate OEF-P.

2. **[SW-OC-P-HB]:** High Bay - 360 Degree Coverage Pattern:

a. 20' to 40' mounting height. Minimum 1.3:1 walking motion coverage pattern to height ratio. Adjustable sensitivity and time delay, integral isolated relay contact. Sensor shall control all luminaires in area.

b. Approved Manufacturers: Watt Stopper HB-300 Series, Hubbell FHB 140 or HMHB series, Leviton OSFHU, Greengate OEF-P.

3. **[SW-O]**: Wall Switch Occupancy Sensor:

a. Passive infrared, zero crossing circuitry, integrated ambient light sensor (10 to 150 FC range), adjustable sensitivity and time delay, no minimum load requirements, manual or auto on operation, Initial settings: 10 minutes, ambient sensor 40 FC. Manual ON for vacancy sensing.

b. Approved Manufacturers: Watt Stopper PW-100 Series, Sensor Switch WSX, Hubbell LHIRS1 or AP1277, Leviton ODS15, Greengate OSW-P-0451.

4. **[SW-O2]**: Dual Wall Switch Occupancy Sensor:

a. Passive infrared, zero crossing circuitry. Switches control two separate circuits or relays. Integrated ambient light sensor (10 to 150 FC range), adjustable sensitivity and time delay, no minimum load requirements, manual or auto on operation, Initial settings: 10 minutes, ambient sensor 40 FC. Manual ON for vacancy sensing.

b. Approved Manufacturers: Watt Stopper PW-200 Series, Sensor Switch WSD-2, Hubbell LHIRD2 or AP127712, Leviton ODS, Greengate OSW-P-0451.

5. **[SW-OC-P-P]**: Ceiling Mounted - 360 Degree Coverage Pattern:

a. Passive infrared, zero crossing circuitry, integrated ambient light sensor (4 to 190 FC Range), adjustable sensitivity and time delay, integral isolated relay contact. Sensor shall control all circuits in the area unless noted otherwise. Initial settings: ambient sensor 40 FC.

b. Approved Manufacturers: Watt Stopper CI Series, Sensor Switch CM-9, Hubbell Automation Omni-IR, Leviton OSC Series, Greengate OMR-P Series.

6. **[SW-OC-P-P2]:** Ceiling Mounted - 100 Degree Coverage Pattern:

a. Passive infrared, zero crossing circuitry, integrated ambient light sensor (4 to 190 FC Range), adjustable sensitivity and time delay, integral isolated relay contact. Sensor shall control all circuits in the area unless noted otherwise. Initial settings: ambient sensor 40 FC.

b. Approved Manufacturers: Watt Stopper WPIR Series, Sensor Switch CM-9, Hubbell LOIRWV or ATD1600W.

7. **[SW-OC-P-W]:** Wall Mounted - 100 Degree Coverage Pattern:

a. Passive infrared, zero crossing circuitry, integrated ambient light sensor (4 to 190 FC range), adjustable sensitivity and time delay, integral isolated relay contact. Sensor shall control all circuits in the area unless noted otherwise. Initial settings: Ambient sensor 40 FC.

b. Approved Manufacturers: Watt Stopper WPIR Series, Sensor Switch CM-9, Hubbell LOIRWV or ATD1600W.

8. With daylight filter and lens to afford coverage applicable to space to be controlled.

E. Ultrasonic Type: Ceiling mounting. Detect occupancy by sensing a change in pattern of reflected ultrasonic energy in area of coverage.

1. **[SW-OC-U]**: 360 Degree 20’ x 20’ Hand Motion Coverage Pattern:

a. Frequency greater than 32 KHz solid state, adjustable sensitivity and time delay, integral isolated 1 amp relay contact, temperature and humidity resistant receivers. Sensor shall control all circuits in area, unless noted otherwise.

b. Approved Manufacturers: Watt Stopper WT-1100 series, Hubbell OMNI-US or ATU series, Leviton OSC series, Greengate ODC-U series.

2. **[SW-OC-U2]**: 35’ x 30’ Hand Motion Coverage Pattern:

a. Frequency greater than 32 KHz solid state, adjustable sensitivity and time delay, integral isolated relay contact, temperature and humidity resistant receivers. Sensor shall control all circuits in area, unless noted otherwise.

b. Approved Manufacturers: Watt Stopper WT-2200 series, Hubbell OMNI-US or ATU series, Leviton OSC series, Greengate ODC-U series.

3. **[SW-OC-U-A]**: 360 Degree Two Sided Corridor Coverage Pattern:

a. Frequency greater than 32 KHz solid state, adjustable sensitivity and time delay, integral isolated relay contact, temperature and humidity resistant receivers. Sensor shall control all circuits in area, unless noted otherwise.

b. Approved Manufacturers: Watt Stopper WT-2250 Series, Hubbell OMNI-US or ATU series, Greengate ODC-U Series.

4. **[SW-OC-U-W]**: Wall Mounted:

a. Wall switch with adjustable settings to allow manual on/auto off or auto on/auto off.

b. Approved Manufacturers: Watt Stopper UW-100 Series, Hubbell AU1277I,

5. Crystal controlled with circuitry that causes no detection interference between adjacent sensors.

2.8 EMERGENCY TRANSFER DEVICES

A. Loss of power on normal circuit shall switch load to emergency power source.

B. Provide suitable NEMA 1 enclosure and mounting per manufacturer specification.

C. **[ETD]**: Emergency Lighting Control Override - Single Luminaire:

1. Rated 2 amps at 120 volt incandescent and 10 amps at 277 volt fluorescent.

2. Approved Manufacturers: Bodine GTD, Iota ETS, Watt Stopper ELCU-100.

D. **[ETD-2]**: Emergency Lighting Control Override - Branch Loads:

1. Rated 1000 watts at 120 volt incandescent and 20 amp at 277 volt fluorescent.

2. Approved Manufacturers: Bodine GTD20, Chloride Lightstar, Dual-Lite ATSD, Nine24 ELCR, Highlites HEPC.

E. **[ETD-D]:** Emergency Lighting Dimming Control Override:

1. Loss of power on normal circuit shall switch luminaires on at 100% rated light output.

2. Approved Manufacturers: Nine24 BLTCv3, nLight nPP16D (ER)

2.9 TIME SWITCH

A. **[TC-30]**: Time switch, 7 day, electronic, 30 setpoints available, LCD display, 12 or 24 hour format, minimum 200 hours battery backup, one SPDT 15 amp contact, UL listed.

1. Approved Manufacturers: Paragon EC71/30S, Tork EW101S, Intermatic ET70115C.

B. **[TC-7]**: Time switch, 7 day, 2 channel, electronic, two SPDT 15 amp contacts, two separate programs with 16 setpoints available, LCD display, 12 or 24 hour format, minimum 100 hours carry-over, UL listed.

1. Approved Manufacturers: Paragon EC72, Tork DTS 200A, Intermatic ET70215C.

C. **[TC-1]**: Astronomical time switch, 7 day, 1 channel, electronic, one SPDT 5 amp contact, LCD display, 12 or 24 hour format, minimum 100 hours carryover, UL listed.

1. Approved Manufacturers: Paragon EC71ST, Tork DWZ100A, Intermatic ET70115C.

D. **[TC-S]**: Timer, 24 hour, 20 amp continuous contacts, 1 N.O. and 1 N.C. contacts, spring wound backup, 120 volt, override switch, UL listed.

1. Approved Manufacturers: Paragon 4213-OS, Tork 7200L, Intermatic T173CR.

2.10 CONDUCTORS AND CABLES

A. Control Wiring:

1. Where installed with the line-voltage wiring, control wiring shall be copper conductors not smaller than No. 16 AWG with insulation voltage rating and temperature rating equal to that of the line-voltage wiring, complying with Division 26 Section 26 05 13 "Wire and Cable."

2. Tap conductors to switches or relays: Stranded copper conductors of 16 AWG or solid 16 or 18 AWG with insulation rating equal to that of the line-voltage wiring.

3. Tap conductors to dimming ballasts: Solid copper conductors of 18 AWG with insulation voltage rating equal to that of the line-voltage wiring and insulation temperature rating not less than 90°C.

4. Network cabling as required by manufacturer.

B. Splices and Taps:

1. Tapping or wire trap connectors shall be used to splice all Class 1 and Class 2 control wiring. Twist-on, wire-nut type connectors are not allowed.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that surfaces are ready to receive work.

B. Verify field dimensions and coordinate physical size of all equipment with the architectural requirements of the spaces into which they are to be installed. Allow space for adequate ventilation and circulation of air.

C. Verify that required utilities are available, in proper location, and ready for use.

D. Beginning of installation means installer accepts existing conditions.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions and approved shop drawings.

B. All wiring shall be installed in conduit.

C. All branch load circuits shall be live tested before connecting the loads to the lighting control panel.

3.3 SUPPORT SERVICES

A. Testing:

1. Programming of initial zones, schedules, lighting levels, control station groups, and sensor settings shall be performed. The following procedures shall be performed at a minimum:

   a. Confirm occupancy sensor placement, sensitivity, and time delay settings to meet specified performance criteria.

   b. Confirm daylight sensor placement, sensitivity, deadband, and delay settings to meet specified performance criteria.

   c. Confirm that schedules and time controls are configured to meet specified performance criteria and Owner's operating requirements.

2. Verify occupancy/vacancy and daylight sensor operation is correct after furniture and equipment is installed in each area. Make adjustments to sensor settings and time delays to allow proper operation.

3. Verify occupancy/vacancy sensors are located to provide complete coverage for the area served with no nuisance switching.

   a. Relocate sensors or provide additional sensors as necessary to provide adequate coverage.

   b. Mask occupancy sensors where necessary to prevent nuisance switching from adjacent areas.

END OF SECTION

SECTION 26 20 00
SERVICE ENTRANCE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Arrangement with Utility Company for permanent electric service
B. Underground service entrance

1.2 RELATED SECTIONS AND WORK

A. Refer to the One-Line Diagram for additional information.

1.3 QUALITY ASSURANCE

A. Utility Company: Madison Gas and Electric.

B. Install service entrance in accordance with Utility Company's rules and regulations.

1.4 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 26 05 00.

B. Submit Utility Company prepared drawings (if applicable).

1.5 SYSTEM DESCRIPTION

A. System Voltage: 208Y/120 volts, three phase, four-wire, 60 Hertz.

PART 2 - PRODUCTS

2.1 METERING EQUIPMENT

A. Meter: Furnished by the Utility Company.

B. Meter Base: Furnished by the Contractor, as approved by the Utility Company. (Manufacturers: Milbank, Superior, Duncan, or Anchor).

C. **[MC-#]:** Exterior Mounted Metering Cabinets: Stainless Steel enclosure. Furnished and installed by the Contractor to Utility Company's specifications. Conduit and conductors between metering cabinets and instrumentation shall be by the Contractor. Connections as required by the Utility Company.

2.2 IDENTIFICATION

A. Provide a permanent plaque or sign denoting all services, feeders, and branch circuits supplying the building or structure and the area served by each. Install plaque or sign at each service disconnecting means.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Make arrangements with Utility Company to obtain permanent electric service to the Project.

B. Primary distribution equipment and pad-mounted transformers shall be furnished and installed by the Utility Company.

C. Primary conductors shall be furnished, installed, and terminated by the Utility Company. Primary conduit shall be furnished and installed by the Contractor, as shown on the drawings, to the Utility Company's requirements.

D. Underground: Install service entrance conduits in concrete envelope from Utility Company's pad mounted transformer to meter cabinet and building service entrance equipment. Utility Company will connect service conductors to transformer secondary lugs.

E. Concrete Pad for Transformer: Furnished and installed by the Contractor to Utility Company's specifications.

END OF SECTION

SECTION 26 24 16
PANELBOARDS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Service and distribution panelboards**: [DP-#], [DP-#]**
B. Lighting and appliance branch circuit panelboards**: [Panel '###']**
C. Fusible branch circuit panelboards**: [Panel '###']**

1.2 RELATED SECTIONS AND WORK

A. Refer to the One-Line Diagram and Panel Schedules for size, rating, and configuration.

1.3 REFERENCES

A. NEMA AB 1 - Molded Case Circuit Breakers

B. NEMA FU 1 – Low voltage cartridge fuses

C. NEMA KS 1 - Enclosed Switches

D. NEMA PB 1 - Panelboards

E. NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less

F. NEMA PB 1.2 - Application Guide for Ground-fault Protective Devices for Equipment

G. UL 248 – Low-Voltage Fuses

H. UL 67 - Panelboards

1.4 SUBMITTALS

A. Submit shop drawings for equipment and component devices under provisions of Section 26 05 00.

B. Include outline and support point dimensions, voltage, main bus ampacity, integrated short circuit ampere rating, circuit breaker and fusible switch arrangement and sizes.

C. Selective coordination study to prove that all essential electrical systems, emergency systems and legally required standby system panelboards are selectively coordinated with all supply side overcurrent protective devices.

1.5 SPARE PARTS

A. Keys: Furnish four (4) each to the Owner.

B. Fuses: Furnish 10% or a minimum of three (3) spare fuses of each type and rating installed to the Owner.

C. Fuse Pullers: Furnish one (1) fuse puller to the Owner.

PART 2 - PRODUCTS

2.1 RATINGS

A. Definitions:

1. Series rated equipment shall be defined as equipment that can achieve a required UL AIC rating with an upstream device such as a main breaker or a combination of devices to meet or exceed a required UL AIC rating. All series rated equipment shall have a permanently attached nameplate indicating that device rating must be maintained. See Section 26 05 53 for additional requirements.

2. Fully rated equipment shall be defined as equipment where all devices in that equipment shall carry a minimum of the AIC rating that is specified.

B. The panelboards for this project shall be fully rated unless otherwise specifically noted in the Drawings or Specifications.

2.2 MAIN AND DISTRIBUTION PANELBOARDS

A. General

1. Approved Manufacturers:

a. Square D QMB, I-Line
b. General Electric Spectra ADS
c. Siemens F2, P4

B. Panelboards: NEMA PB 1; type as shown on the drawings.

C. Enclosure: NEMA PB 1; Type 1.

D. Provide cabinet front with concealed trim clamps and hinged trim on door to allow access to wiring gutters without removal of trim and flush lock. Finish in manufacturer's standard gray enamel.

E. Provide panelboards with copper bus, ratings as scheduled on the drawings. Provide copper ground bus in all panelboards.

F. All spaces shown on the one-line diagram shall be fully prepared spaces for future breakers.

G. Minimum Integrated Short Circuit Rating: 100,000 amperes rms symmetrical for 240 volt panelboards; 50,000 amperes rms symmetrical for 480 volt panelboards, or as shown on the drawings.

H. Fusible Switch Assemblies: NEMA KS 1; quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle. Provide interlock to prevent opening front cover with switch in ON position. Handle lockable in OFF position.

I. Fuse Clips (Switches 600 Amperes and Smaller): Provide with Class 'R' rejection clips. Fuse Clips (601 Amperes and Larger): Designed to accommodate Class 'L' fuses.

J. Molded Case Circuit Breakers: Provide circuit breakers with integral thermal and instantaneous magnetic trip in each pole.

K. Solid State Molded Case Circuit Breakers: **(All breakers identified on plans as solid-state with 1,200 ampere frame sizes and below.)** Provide molded case switch with electronic sensing, timing, and tripping circuits for fully adjustable time current characteristic settings including ground fault trip, instantaneous trip, long time trip, long time delay, short time trip, and short time delay. Trip setting shall be field programmable with a sealable clear cover.

L. Arc Energy Reduction:

1. Provide an arc energy reduction system to reduce the clearing time of an arc flash event. The arc energy reduction system shall be provided for overcurrent protection devices rated 1,000 amps or larger.

2. Energy-Reducing Maintenance Switch: Provide an energy-reducing maintenance switch visual status indication when engaged. Install the maintenance switch at the entrance to the electrical room.

M. Suitable for use as service entrance equipment.

N. **[DPM]:** Digital AC Power Monitor. Capable of measuring, calculating and directly displaying; Volts (L-L, L-N), Amps, KW, KWH. Monitor shall be true RMS measurement with programmable set-up parameters. All set-up parameters data shall be stored in non-volatile memory to protect from power outages.

2.3 BRANCH CIRCUIT PANELBOARDS

A. General

1. Approved Manufacturers:

a. Square D NQ, NF
b. General Electric AQ, AE
c. Siemens P1

B. Lighting and Appliance Branch Circuit Panelboards: NEMA PB 1; circuit breaker type.

C. Enclosure: NEMA PB 1; Type 1.

D. Provide cabinet front with door-in-door construction, concealed hinge, and flush lock all keyed alike. Finish in manufacturer's standard gray enamel.

E. Provide panelboards with copper bus, ratings as scheduled on the drawings. Provide copper ground bus in all panelboards.

F. All unlabeled circuits shown on the panelboard schedule shall be fully prepared spaces for future breakers.

G. All multiple-section panelboards shall have the same dimensional back box and cabinet front size.

H. Minimum Integrated Short Circuit Rating: As shown on the drawings.

I. Provide handle lock-on devices for all breakers serving exit sign and lighting circuits with emergency battery units. Provide handle lock-on devices and red handles for breakers serving fire alarm panels.

J. Molded Case Circuit Breakers: Bolt-on type thermal magnetic trip circuit breakers, with common trip handle for all poles. Provide circuit breakers UL listed as Type SWD for lighting circuits. Provide UL Class A ground fault interrupter circuit breakers where scheduled on the drawings. Do not use tandem circuit breakers.

K. Current Limiting Molded Case Circuit Breakers: Provide circuit breakers with integral thermal and instantaneous magnetic trip in each pole, coordinated with automatically resetting current limiting elements in each pole. Interrupting rating 100,000 symmetrical amperes, let-through current and energy level less than permitted for same size Class RK-5 fuse.

2.4 FUSIBLE BRANCH CIRCUIT PANELBOARDS

A. General

1. Approved Manufacturers:

a. Bussmann
b. Littelfuse
c. Mersen MFCP

B. Provide cabinet front with concealed hinge and flush lock all keyed alike. Finish in manufacturer's standard gray enamel.

C. Provide panelboards with copper bus, ratings as scheduled on the drawings. Provide copper ground bus in all panelboards.

D. Overcurrent protective devices shall be UL listed, with voltage, amperage, number of poles, and short-circuit current rating as shown on the panelboard schedule. Multi-pole branch circuit protection devices shall trip on an overcurrent of any pole to prevent single-phasing of the load.

E. Fuse holder shall be finger-safe with trim installed. Fuses shall only be removable when terminals are not energized.

F. All unlabeled circuits shown on the panelboard schedule shall be fully prepared spaces for future fuse units.

G. All multiple-section panelboards shall have the same dimensional backbox and cabinet front size.

H. Minimum Integrated Short Circuit Rating: As shown on the drawings.

I. Branch fuse disconnect shall have visible ON/OFF indication, blown fuse indicating lights, and permanently installed lockout means.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install panelboards plumb as indicated on the drawings in conformance with NEMA PB 1.1.

B. Height: 6 feet to handle of highest device.

C. Provide filler plates for unused spaces in panelboards.

D. Provide typed circuit directory for each branch circuit panelboard. Label each circuit with the type of load and the name and number of the area served. Revise directory to reflect circuit changes required to balance phase loads.

E. Stub five (5) empty one inch conduits to accessible location above ceiling out of each recessed panelboard.

F. Install fuses in fusible switch assemblies.

3.2 FIELD QUALITY CONTROL

A. Measure steady state load currents at each panelboard feeder. Should the difference at any panelboard between phases exceed 20 percent, rearrange circuits in the panelboard to balance the phase loads within 20 percent. Take care to maintain proper phasing for multi-wire branch circuits.

B. Visual and Mechanical Inspection: Inspect for physical damage, proper alignment, anchorage, and grounding. Check proper installation and tightness of connections for circuit breakers, fusible switches, and fuses.

END OF SECTION

SECTION 26 24 19
MOTOR CONTROL

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Manual motor starters
B. Magnetic motor starters
C. Combination magnetic motor starters

1.2 RELATED SECTIONS AND WORK

A. Refer to the Disconnect and Starter Schedule and One-Line Diagram for rating and configuration.

1.3 REFERENCES

A. ANSI/UL Standard 508. Standard for Industrial Control Equipment

B. FCC Rules and Regulations, Part 15, Subpart J- Radio Frequency Interference

C. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service

D. FS W-F-870 - Fuseholders (For Plug and Enclosed Cartridge Fuses)

E. FS W-P-115 - Power Distribution Panel

F. FS W-S-865 - Switch, Box, (Enclosed), Surface-Mounted

G. IEEE Standard 519-1981 - Guide for Harmonic Control and Reactive Compensation of Static Power Converters

H. NEMA AB 1 - Molded Case Circuit Breakers

I. NEMA ICS 2 - Industrial Control Devices, Controllers, and Assemblies

J. NEMA ICS 6 - Enclosures for Industrial Controls and Systems

K. NEMA KS 1 - Enclosed Switches

L. NEMA PB 1 - Panelboards

M. NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or less

1.4 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 26 05 00.

B. Indicate on shop drawings, front and side views of motor control center enclosures with overall dimensions. Include conduit entrance locations and requirements; wiring diagrams that differentiate between manufacturer-installed and field-installed wiring; nameplate legends; size and number of bus bars per phase, neutral, and ground; electrical characteristics including voltage, frame size and trip ratings, withstand ratings, and time-current curves of all equipment and components.

C. Provide product data on motor starters and combination motor starters, relays, pilot devices, and switching and over-current protective devices.

D. Submit manufacturer's instructions under provisions of Section 26 05 00.

1.5 SPARE PARTS

A. Keys: Furnish four (4) each to the Owner.

B. Fuses: Furnish three (3) spare fuses of each type and rating installed to the Owner.

C. Fuse Pullers: Furnish one (1) fuse puller to the Owner.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 26 05 00.

B. Deliver in 60 inch maximum width shipping splits, individually wrapped for protection, and mounted on shipping skids.

C. Store and protect products under provisions of Section 26 05 00.

D. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from fumes, dirt, water, construction debris, traffic, and physical damage.

E. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to motor control center components, enclosure, and finish.

1.7 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 26 05 00.

B. Include spare parts data listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.

PART 2 - PRODUCTS

2.1 MANUAL MOTOR STARTERS

A. Manual Motor Starter: NEMA ICS 2; AC general-purpose Class A manually operated non-reversing full-voltage controller for induction motors rated in horsepower, with overload relay, and toggle operator.

B. Fractional Horsepower Manual Starter: NEMA ICS 2; AC general-purpose Class A manually operated, full-voltage controller for fractional horsepower induction motors, with thermal overload unit, and toggle operator.

C. Motor Starting Switch: NEMA ICS 2; AC general-purpose Class A manually operated, full-voltage controller for fractional horsepower induction motors, without thermal overload unit, and toggle operator.

D. Enclosure: NEMA ICS 6; Type 1.

2.2 MAGNETIC MOTOR STARTERS

A. Magnetic Motor Starters: NEMA ICS 2; AC general-purpose Class A magnetic controller for induction motors rated in horsepower.

B. Full Voltage Starting: Non-reversing type, unless otherwise indicated.

C. Coil Operating Voltage: 120 volts, 60 Hertz, obtained from integral control power transformer of sufficient capacity to operate connected pilot, indicating, and control devices, plus 100% spare capacity.

D. Size: NEMA ICS 2; size as shown on the drawings.

E. Overload Relay:

1. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, Class 20 tripping characteristic. Provide with heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.

F. Enclosure: NEMA ICS 6; Type 1.

G. Combination Motor Starters: Combine motor starters with disconnect switch in common enclosure. Provide with disconnecting means as indicated on drawings.

H. Auxiliary Contacts: NEMA ICS 2; two normally open, field convertible contacts in addition to seal-in contact.

I. Pushbuttons: NEMA ICS 2; START/STOP in front cover.

J. Indicating Lights: NEMA ICS 2; RUN: red in front cover.

K. Selector Switches: NEMA ICS 2; HAND/OFF/AUTO, in front cover.

L. Relays: NEMA ICS 2.

M. Control Power Transformers: 120 volt fused secondary, fused primary, minimum VA as scheduled:

Size 1 - 100 VA
Size 2 - 100 VA
Size 3 - 150 VA
Size 4 - 300 VA
Size 5 - 300 VA
Size 6 - 300 VA

N. Provide phase loss protection relay with contacts to de-energize the starter for each starter serving motors 5 HP or greater.

2.3 CONTROLLER OVER-CURRENT PROTECTION AND DISCONNECTING MEANS

A. Molded Case Thermal-Magnetic Circuit Breakers: Circuit breakers with integral thermal and instantaneous magnetic trip in each pole. NEMA AB 1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

B. Non-fusible Switch Assemblies: Quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle. Provide interlock to prevent opening front cover with switch in ON position. Handle lockable in OFF position.

C. Fusible Switch Assemblies: NEMA KS 1, quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle. Provide interlock to prevent opening front cover with switch in ON position. Handle lockable in OFF position. Fuse Clips: Provide with Class' R' rejection clips. Select and size fuses to provide Type 2 protection according to IEC 947-4-1, as certified by a nationally recognized testing laboratory.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install motor control equipment in accordance with manufacturer's instructions on concrete bases.

B. Install fuses in fusible switches.

C. Select and install heater elements in motor starters to match installed motor characteristics.

D. Set field-adjustable switches and circuit-breaker trip ranges.

E. Motor Data: Provide neatly typed label inside each motor starter enclosure door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating.

END OF SECTION

SECTION 26 27 26
WIRING DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Device plates and box covers
B. Receptacles
C. Floor boxes
D. Service fitting
E. Pendant cord/connector devices
F. Cord and plug sets
G. Cord reel

1.2 QUALITY ASSURANCE

A. Provide similar devices from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in the NEC Article 100, by a testing agency to Authorities Having Jurisdiction and marked for intended use.

C. Comply with the NEC.

1.3 REFERENCES

A. DSCC W-C-896F – General Specification for Electrical Power Connector
B. FS W-C-596 - Electrical Power Connector, Plug, Receptacle, and Cable Outlet
C. NEMA WD 1 – General Color Requirements for Wiring Devices
D. NEMA WD 6 – Wiring Devices – Dimensional Requirements
E. NFPA 70 - National Electrical Code (NEC)
F. UL 498 – Standard for Attachment Plugs and Receptacles
G. UL 943 – Standard for Ground Fault Circuit Interrupters

1.4 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

B. Provide product data showing configurations, finishes, dimensions, and manufacturer's instructions.

C. Submit manufacturer occupancy sensor coverage patterns applicable to this project. For areas requiring multiple sensor devices for appropriate coverage, submit specific manufacturer approved sensor layout as an overlay directly on the project drawings, either in print or approved electronic form.

1.5 COORDINATION

A. Receptacles for Owner Furnished Equipment: Match plug configurations.

B. Cord and Plug Sets: Match equipment requirements.

PART 2 - PRODUCTS

2.1 DEVICE COLOR

A. All switch, receptacle, outlet, and coverplate colors shall be verified with Architect, unless indicated otherwise.

2.2 COVERPLATES

A. All switches, receptacles, and outlets shall be complete with the following:

1. Unbreakable thermoplastic/thermoset plastic coverplates in finished spaces where walls are finished.

2. #302 stainless steel coverplates in unfinished spaces for flush boxes.

3. Galvanized steel coverplates in unfinished spaces for surface mounted boxes.

B. Where several devices are ganged together, the coverplate shall be of the ganged style for the number of devices used.

C. Install nameplate identification as indicated in Section 26 05 53.

D. Plate securing screws shall be metal with head color matching the wall plate finish.

2.3 RECEPTACLES

A. Refer to Electrical Symbols List for device type.

B. Devices that are shaded on the drawings shall be red.

C. **[REC-DUP]**: NEMA 5-20R Duplex Receptacle:

1. 125 volt, 20 amp, 3-wire grounding type heavy duty industrial grade with impact resistant thermoplastic face and one-piece brass back strap with integral ground contacts.

2. Approved Manufacturers: Hubbell 5362, Leviton 5362, Pass & Seymour 5362A, Cooper AH5362.

D. **[REC-DUP-GFI]**: NEMA 5-20R Ground Fault Duplex Receptacle:

1. 125 volt, 20 amp, 3-wire grounding type with test and reset buttons in impact resistant thermoplastic face.

2. Device shall perform self-test of GFCI circuitry in accordance with UL 943.

3. Approved Manufacturers: Hubbell GF20L, Leviton GFNT2, Pass & Seymour 2097, Cooper SGF20.

E. **[REC-DUP-GFI-R]**: Remote Ground Fault Device:

1. Ground fault device for remote downstream receptacles. 125 volt, 20 amp. Test and reset buttons in impact resistance thermoplastic face.

2. Approved Manufacturers: Hubbell GFBF20, Leviton 6895, Pass & Seymour 2085, Cooper VGFD20.

F. **[REC-DUP-WP]**: NEMA 5-20R Weatherproof Ground Fault Duplex Receptacle:

1. 125 volt, 20 amp, 3-wire grounding type with test and reset buttons in impact resistant thermoplastic face. Provide NEMA 3R rated while-in-use cast aluminum cover.

2. Device shall perform self-test of GFCI circuitry in accordance with UL 943.

3. Approved Manufacturers: Hubbell GFTR20/(RW57300) WP826, Leviton GFWT2/(5977-CL) M5979, Pass & Seymour 2097TRWR/(WIUC10-C) WIUCAST1, Cooper WRSGF20/(WIU-1) WIUMV-1.

G. **[REC-USB]**: NEMA 5-20R Receptacle with USB Charger:

1. 125 volt, 20 amp, tamper resistant, 3-wire grounding type with impact resistant thermoplastic face. Type A USB charging rated at 5VDC 2.1A. Mounted in double gang backbox.

2. Approved Manufacturers: Hubbell USB20X2, Pass & Seymour TR5362USB, Cooper TR7766.

H. **[REC-ARC]**: NEMA 5-20R Receptacle with Arc Fault Circuit Interrupts

1. 125 volt, 20 amp, 3-wire grounding type hospital grade, arc fault circuit interrupter receptacle with test and reset buttons in impact resistant thermoplastic face.

2. Approved Manufacturers: Leviton AFTR2.

I. **[REC-SIM-520R]**: NEMA 5-20R Simplex Receptacle:

1. 125 volt, 20 amp, 3-wire grounding type with impact resistant thermoplastic face.

2. Approved Manufacturers: Hubbell HBL5361, Leviton, 5361, Pass & Seymour 5361, Cooper 5361.

J. **[REC-SIM-530R]**: NEMA 5-30R Simplex Receptacle:

1. 125 volt, 30 amp, 3-wire grounding type, phenolic face.

2. Approved Manufacturers: Hubbell HBL9308, Leviton 5371, Pass & Seymour 3802, Cooper 5716N.

K. **[REC-SIM-550R]**: NEMA 5-50R Simplex Receptacle:

1. 125 volt, 50 amp, 3-wire grounding type, phenolic face.

2. Approved Manufacturers: Hubbell HBL9360, Cooper 1253.

L. **[REC-SIM-620R]**: NEMA 6-20R Simplex Receptacle:

1. 250 volt, 20 amp, 2-pole, 3-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL5461, Leviton 5461, Pass & Seymour 5871, Cooper 5461.

M. **[REC-SIM-630R]**: NEMA 6-30R Simplex Receptacle:

1. 250 volt, 30 amp, 2-pole, 3-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL9330, Leviton 5372, Pass & Seymour 3801, Cooper 5700N.

N. **[REC-SIM-650R]**: NEMA 6-50R Simplex Receptacle:

1. 250 volt, 50 amp, 2-pole, 3-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL9367, Leviton 5374, Pass & Seymour 3804, Cooper 5709N.

O. **[REC-SIM-720R]**: NEMA 7-20R Simplex Receptacle:

1. 277 volt, 20 amp, 2-pole, 3-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell, Leviton, Pass & Seymour 7621.

P. **[REC-SIM-730R]**: NEMA 7-30R Simplex Receptacle:

1. 277 volt, 30 amp, 2-pole, 3-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL9315, Leviton 9730-A, Pass & Seymour, Cooper 5795N.

Q. **[REC-SIM-750R]**: NEMA 7-50R Simplex Receptacle:

1. 277 volt, 50 amp, 2-pole, 3-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL9365, Leviton 9750-A, Pass & Seymour, Cooper.

R. **[REC-SIM-1420R]**: NEMA 14-20R Simplex Receptacle:

1. 125/250 volt, 20 amp, 3-pole, 4-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL8410, Pass & Seymour 3820, Cooper 5759.

S. **[REC-SIM-1430R]**: NEMA 14-30R Simplex Receptacle:

1. 125/250 volt, 30 amp, 3-pole, 4-wire grounding type with thermoplastic face. Flush mounted at +24 AFF.

2. Approved Manufacturers: Hubbell HBL9430A, Leviton 278, Pass & Seymour 3864, Cooper 5744N.

T. **[REC-SIM-1450R]**: NEMA 14-50R Simplex Receptacle:

1. 125/250 volt, 50 amp, 3-pole, 4-wire grounding type with thermoplastic face. Flush mounted at +4" AFF.

2. Approved Manufacturers: Hubbell HBL9450A, Leviton 279, Pass & Seymour 3894, Cooper 5754N.

U. **[REC-SIM-1460R]**: NEMA 14-60R Simplex Receptacle:

1. 125/250 volt, 60 amp, 3-pole, 4-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL9460A, Leviton 9460, Pass & Seymour, Cooper 9460N.

V. **[REC-SIM-1520R]**: NEMA 15-20R Simplex Receptacle:

1. 250 volt, 20 amp, 3-phase, 3-pole, 4-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL8420, Leviton, Pass & Seymour, Cooper.

W. **[REC-SIM-1530R]**: NEMA 15-30R Simplex Receptacle:

1. 250 volt, 30 amp, 3-phase, 3-pole, 4-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL8430A, Leviton 8430, Pass & Seymour 5740, Cooper 8430N.

X. **[REC-SIM-1550R]**: NEMA 15-50R Simplex Receptacle:

1. 250 volt, 50 amp, 3-phase, 3-pole, 4-wire grounding type with thermoplastic face.
2. Approved Manufacturers: Hubbell HBL8450A, Leviton 8450, Pass & Seymour 5750, Cooper 8450N.

Y. **[REC-SIM-1560R]**: NEMA 15-60R Simplex Receptacle:

1. 250 volt, 60 amp, 3-phase, 3-pole, 4-wire grounding type with thermoplastic face.
2. Approved Manufacturers: Hubbell HBL9460A, Pass & Seymour 5760, Cooper 8460N.

Z. **[REC-SIM-L520R]**: NEMA L5-20R Simplex Receptacle, Locking Type:

1. 125 volt, 20 amp, 2-pole, 3-wire grounding type with impact resistant thermoplastic face.
2. Approved Manufacturers: Hubbell, Leviton, Pass & Seymour L520, Cooper CWL520R.

AA. **[REC-SIM-L530R]**: NEMA L5-30R Simplex Receptacle Locking Type:

1. 125 volt, 30 amp, 2-pole, 3-wire grounding type with impact resistant thermoplastic face.
2. Approved Manufacturers: Hubbell, Leviton, Pass & Seymour L530, Cooper CWL530R.

BB. **[REC-SIM-L620R]**: NEMA L6-20R Locking Type Simplex Receptacle:

1. 250 volt, 20 amp, 2-pole, 3-wire grounding type with thermoplastic face.
2. Approved Manufacturers: Hubbell HBL2320, Leviton 2320, Pass & Seymour L620R, Cooper CWL620R.

CC. **[REC-SIM-L630R]**: NEMA L6-30R Locking Type Simplex Receptacle:

1. 250 volt, 30 amp, 2-pole, 3-wire grounding type with thermoplastic face.
2. Approved Manufacturers: Hubbell HBL2620, Leviton 2620, Pass & Seymour L630R, Cooper CWL630R.

DD. **[REC-SIM-L720R]**: NEMA L7-20R Locking Type Simplex Receptacle:

1. 277 volt, 20 amp, 2-pole, 3-wire grounding type with thermoplastic face.
2. Approved Manufacturers: Hubbell HBL2330, Leviton 2330, Pass & Seymour L720R, Cooper CWL720R.

EE. **[REC-SIM-L730R]**: NEMA L7-30R Locking Type Simplex Receptacle:

1. 277 volt, 30 amp, 2-pole, 3-wire grounding type with thermoplastic face.
2. Approved Manufacturers: Hubbell HBL2630, Leviton 2630, Pass & Seymour L730R, Cooper CWL730R.

FF. **[REC-SIM-L1420R]**: NEMA L14-20R Locking Type Simplex Receptacle:

1. 125/250 volt, 20 amp, 3-pole, 4-wire grounding type with thermoplastic face.
2. Approved Manufacturers: Hubbell HBL 2410, Pass & Seymour L1420, Cooper CWL1420R.

GG. **[REC-SIM-L1430R]**: NEMA L14-30R Locking Type Simplex Receptacle:

1. 125/250 volt, 30 amp, 3-pole, 4-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL 2710, Leviton 2710, Pass & Seymour L1430R, Cooper CWL1430R.

HH. **[REC-SIM-L1520R]**: NEMA L15-20R Locking Type Simplex Receptacle:

1. 250 volt, 20 amp, 3-phase, 3-pole, 4-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL2420, Leviton 2420, Pass & Seymour L1520R, Cooper CWL1520R.

II. **[REC-SIM-L1530R]**: NEMA L15-30R Locking Type Simplex Receptacle:

1. 250 volt, 30 amp, 3-phase, 3-pole, 4-wire grounding type with thermoplastic face.

2. Approved Manufacturers: Hubbell HBL2720, Leviton 2720, Pass & Seymour L1530R, Cooper CWL1530R.

JJ. **[REC-SIM-L2120R]**: NEMA L21-20R Locking Type Simplex Receptacle:

1. 120/208Y 3 phase 20 amp 5 wire grounding type.

2. Approved Manufacturers: Hubbell HBL2510, Cooper CWL2120R, Pass & Seymour L2120R.

KK. **[REC-SIM-L2130R]**: NEMA L21-30R Locking Type Simplex Receptacle:

1. 120/208Y 3 phase 30 amp 5 wire grounding type.

2. Approved Manufacturers: Hubbell HBL2750, Cooper CWL2130R, Pass & Seymour L2130R.

LL. **[REC-TAMP]**: NEMA 5-20R Tamper Resistant Duplex Receptacle:

1. 125 volt, 20 amp, 3-wire grounding type with impact resistant thermoplastic face.

2. Approved Manufacturers: Hubbell BR20TR, Leviton TBR20, Pass & Seymour TR5362, Cooper TRBR20.

3. Provide decorative style duplex tamper resistant receptacles in public spaces where walls are finished.

4. Approved Manufacturers: (Decorative), Hubbell DR20TR, Leviton TDR20, Pass & Seymour TR2635.

MM. **[REC-TAMP-GFI]**: NEMA 5-20R GFI Tamper Resistant Receptacle:

1. 125 volt, 20 amp, 3-wire grounding type tamper-resistant with test and reset buttons in impact resistant thermoplastic face.

2. Device shall perform self-test of GFCI circuitry in accordance with UL 943.

3. Approved Manufacturers: Hubbell GFTR20, Cooper TRSGF20, Pass & Seymour 2097TR, Leviton GFTR2.

NN. **[REC-TAMP-QUAD]**: NEMA 5-20R Double Duplex Tamper Resistant Receptacle:

1. Consists of two duplex tamper resistant receptacles, double gang box, plaster ring and faceplate.

2. Approved Manufacturers: Refer to Tamper Resistant Receptacle above.

OO. **[REC-DUP-O]**: NEMA 5-20R Plug Load Controlled Duplex Receptacle:

1. 125 volt, 20 amp, 3-wire grounding type with impact resistant thermoplastic face and steel back strap. Bottom half of duplex shall be split circuit wired and controlled by remote relay. Controlled receptacle shall have permanent NEMA approved and NEC 2014 compliant marking on face of device.

2. Approved Manufacturers: Pass & Seymour 5362H, Leviton 5362-1P, Hubbell, Cooper.

PP. **[REC-QUAD-O]**: NEMA 5-20R Plug Load Controlled Duplex Receptacle:

1. Consists of two duplex tamper resistant receptacles, double gang box, plaster ring and faceplate.

2. Approved Manufacturers: Refer to Plug Load Controlled Duplex Receptacles above.

QQ. **[REC-QUAD]:** NEMA 5-20R Double Duplex Receptacle:

1. Consists of two duplex receptacles, double gang box, plaster ring and faceplate.

2. Approved manufacturers: Refer to Duplex Receptacle above.

RR. **[REC-QUAD-GFI]**: NEMA 5-20R Double Duplex GFI Receptacle:

1. Consists of two duplex GFI receptacles, double gang box, plaster ring and faceplate.

2. Approved Manufacturers: Refer to Duplex GFI Receptacle above.

SS. **[REC-QUAD-USB]**: NEMA 5-20R Double Duplex USB Receptacle:

1. Consists of two duplex USB receptacles, double gang box, plaster ring and faceplate.

2. Approved Manufacturers: Refer to USB Receptacle above.

TT. **[REC-QUAD-WP]**: NEMA 5-20R Weatherproof Ground Fault Quad Receptacle:

1. Consists of two duplex, GFI receptacles. Double gang box. Provide NEMA 3R rated while-in-use cast aluminum cover.

2. Approved Manufacturers:

   a. Receptacle: Refer to GFCI Receptacle above.

   b. Cover: Intermatic WP1030MXD, Pass & Seymour WIUCAST2, Thomas & Betts Red Dot 2CKU.

UU. Back wired devices shall be complete with eight holes that are screw activated with metal clamps for connection to #12 or #10 copper conductors.

VV. Side wired devices shall have four binding screws that are undercut for positive wire retention.

WW. Ground fault circuit interrupter (GFCI) receptacles shall comply with UL 943 requiring increased surge immunity, improved corrosion resistance, improved resistance to false tripping and diagnostic indication for miswiring if the line and load conductors are reversed during installation.

XX. Integral surge suppression receptacles with integral surge suppression shall comply with the following:

1. Category A3 listed.

2. Line to ground, line to neutral, and neutral to ground modes.

3. Metal-oxide varistors with a nominal clamp level rating of 500 volts and minimum single transient pulse energy dissipation of 210 joules per mode.

4. Status indication: Light visible in the face of the device and audible alarm to indicate device is no longer active or in service.

5. Distinctive symbol on device face to denote SPD-type device.

6. Device shall be blue.

7. NEMA 5-20R duplex receptacle, 125 volt, 20 amp, 3-wire grounding type heavy duty industrial grade with impact resistant thermoplastic face and one-piece brass back strap.

a. Approved Manufacturers: Hubbell HBL5362SA, Leviton, Pass & Seymour, Cooper.

YY. Hazardous (Classified) location receptacles shall comply with NEMA FB 11.

2.4 FLOOR BOXES

A. Color: Verify with Architect.

B. Coordinate with Technology drawings for voice/data outlet requirements.

C. Floor Boxes for Installation in Cast-In-Place Concrete Floors: Fully adjustable, cast iron.

D. **[FB-1]**: Cast iron floor box, dual compartment, flush mount, brass carpet flange. One compartment with one (1) **[REC-DUP]** and brass duplex flap cover. One compartment with brass 2-1/8" x 3/4" combination cover and one (1) 3/4" and one (1) 1" conduit stubbed to above the lay-in ceiling.

1. Approved Manufacturers:

a. Hubbell

E. **[FB-2]**: Cast iron floor box, dual compartment, flush mount, brass carpet flange. One compartment with one (1) **[REC-DUP]** and brass duplex flap cover. One compartment with brass 2-1/8" x 3/4" combination cover and one (1) 3/4" and one (1) 1" conduit stubbed to above the lay-in ceiling.

1. Approved Manufacturers:

a. Hubbell

2.5 PENDANT CORD/CONNECTOR DEVICES

A. Description: Matching, locking type plug and receptacle body connector, NEMA WD 6, Configurations L5-20P and L5-20R, heavy-duty grade or refer to Details as shown on drawings.

1. Body: Nylon with screw-open cable gripping jaws and provisions for attaching external cable grip.

B. External Cable Grip: Woven wire mesh type made of high strength galvanized steel wire stand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.6 CORD AND PLUG SETS

A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.

1. Cord: Rubber-insulated, stranded copper conductors, with Type SOW-A jacket; with green insulated grounding conductor and equipment rating ampacity plus a minimum of 30 percent.

2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection, FS/UL listed.

2.7 CORD REELS

A. **[CR-1]**: 50' 3#12 AWG type 'SOW-A' cord with adjustable ball stop. 120 volt, NEMA 5-20R, simplex receptacle connector, rated 16 amps continuous.

1. Approved Manufacturers:

a. Daniel Woodhead w/ Hubbell
b. Appleton
c. Hubbell HBL

B. **[CR-2]**: 50' 3#10 AWG type 'SOW-A' cord with adjustable ball stop. 120 volt, NEMA 5-30R, simplex receptacle connector, rated 20 amps continuous.

1. Approved Manufacturers:

a. Daniel Woodhead w/ Hubbell
b. Appleton
c. Hubbell HBL

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install light switches, dimmers, and convenience receptacles at elevations indicated in the General Installation Notes on the contract drawings.

B. Install specific-use receptacles at heights shown on the contract drawings. Install devices level, plumb, and square with building lines. Coordinate installation of adjacent devices of separate systems with common mounting heights, including lighting, power, systems, technology, and temperature control device rough-ins.

C. Drill opening for poke-through fitting installation in accordance with manufacturer's instructions. This Contractor is responsible for taking any measures required to ensure no conduits or other services are damaged. This may include X-ray or similar non-destructive means.

D. Install receptacles vertically with ground slot up or where indicated on the drawings, horizontally with ground slot to the left.

E. Install decorative plates on switch, receptacle, and blank outlets in finished areas, using jumbo size plates for outlets installed in masonry walls.

F. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface-mounted outlets.

G. Install devices and wall plates flush and level.

H. Contractor to verify that wall dimmer ratings are achieved where a ganged installation is used.

I. Install nameplate identification to receptacle cover plates indicated. Identification shall identify panel name and circuit number. Refer to Specification Section 26 05 53 - Electrical Identification.

J. Identify locations of power packs, control units, and relays above ceiling on record drawing.

K. Test receptacles for proper polarity, ground continuity and compliance with requirements.

L. Healthcare devices shall be tested in accordance with NFPA 99 6.3.3 for grounding, voltage, and impedance measurements.

M. Floor Box Installation:

1. Set boxes level and flush with finish flooring material.

2. Use cast iron floor boxes for installations in slab on grade. Trim shall match floor covering to be used.

3. Provide a minimum horizontal offset of 24 inches between boxes.

4. Provide saw-cutting and patching of existing concrete floors as necessary for floor box installations within existing floors.

END OF SECTION

SECTION 26 28 13
FUSES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fuses
B. Spare Fuse Cabinet

1.2 REFERENCES

A. UL 198C - High-Interrupting Capacity Fuses; Current Limiting Types

B. UL 198E - Class R Fuses

C. FS W-F-870 - Fuseholders (For Plug and Enclosed Cartridge Fuses)

D. NEMA FU 1 - Low Voltage Cartridge Fuses

E. NFPA 70 – National Electrical Code

1.3 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

1.4 EXTRA MATERIALS

A. Provide two fuse pullers.

B. Provide three of each size and type of fuse installed.

1.5 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40°F (5°C) or more than 100°F (38°C), apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS – FUSES

A. Cooper Bussman
B. Eagle Electric Mfg. Co.; Cooper Industries
C. Mersen
D. Tracor; Littelfuse Subsidiary

2.2 FUSES

A. Dimensions and Performance: NEMA FU 1, Class as specified or indicated.

B. Voltage: Provide fuses with voltage rating suitable for circuit phase-to-phase voltage.

C. Fuses with ratings larger than 600 amperes: Class L (time delay), unless otherwise noted on the drawings.

D. Fuses with ratings larger than 200 amperes but equal to or less than 600 amperes: Class RK-1 (time delay), unless otherwise noted on the drawings.

E. Fuses with ratings less than or equal to 200 amperes (not including control transformer fuses): Class RK-5, unless otherwise noted on the drawings.

F. Control transformer fuses: Class CC (time delay).

G. Fuses for packaged equipment: Size and type as recommended by equipment manufacturer.

2.3 **SPARE FUSE CABINET**

A. Cabinet: Wall-mounted, 0.05-inch- (1.27-mm-) thick steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
2. Finish: Gray, baked enamel.
3. Identification: "SPARE FUSES" in 1-1/2-inch- (38-mm-) high letters on exterior of door.
4. Fuse Pullers: For each size of fuse.

PART 3 - EXECUTION

3.1 **INSTALLATION**

A. Install fuses where indicated on the drawings and specifications.

B. Install fuses in accordance with manufacturer's instruction.

C. Install fuses in packaged equipment as required by equipment manufacturer.

D. Install fuse with label oriented such that manufacturer, type, and size are easily read.

E. Install spare fuse cabinet in the Main Electrical Room.

END OF SECTION

SECTION 26 28 16
DISCONNECT SWITCHES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fusible switches
B. Non-fusible switches
C. Molded case circuit switches
D. Molded case switches
E. Motor disconnect switch
F. Enclosures

1.2 RELATED SECTIONS AND WORK

A. Refer to the Disconnect and Starter Schedule for rating and configuration.

1.3 REFERENCES

A. NEMA KS 1 - Enclosed Switches

1.4 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

B. Product Data: For each type of enclosed switch, circuit breaker, accessory and component indicated, include dimensions, weights, and manufacturer's technical data on features, performance, and ratings.

C. Electrical Characteristics: For each type of enclosed switch, enclosure types, current and voltage ratings, short-circuit current ratings, UL listing for series rating of installed devices, features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

1.5 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 FUSIBLE AND NON-FUSIBLE SWITCHES

A. **[FDS-#]:** Fusible Switch Assemblies: NEMA KS 1; Type heavy duty, quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position. Fuse Clips: Class 'R' fuse clips only, unless indicated otherwise on the drawings.

B. **[DS-#]:** Non-fusible Switch Assemblies: NEMA KS 1; Type heavy duty, quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position.

C. Enclosures: Type as indicated on the disconnect schedule.

D. Accessories: As indicated on the disconnect schedule.

2.2 MOLDED CASE CIRCUIT BREAKERS AND SWITCHES

A. **[CB-#]:** Molded Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.

1. Thermal Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. Adjustable Instantaneous Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip settings.

3. Electronic Trip Unit Circuit Breakers: RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:

   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long- and short-time adjustments.
   d. Ground-fault pickup level, time delay, and I^2t responses.

4. Current Limiting Circuit Breakers: Frame sizes 400 A and smaller and let-through ratings less than NEMA FU 1, RK-5.

B. **[CB-#]:** Molded Case Switches: Molded case circuit breaker with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

C. Accessories: As indicated on the disconnect schedule.

2.3 MOTOR DISCONNECT SWITCH

A. **[DS-#]:** Rotary Switch Assemblies: Rated for making and breaking loads, rotary type enclosed switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position.

B. Enclosures: Type as indicated on the Disconnect Schedule.

C. Ground lug connection provided in enclosure.

D. Accessories: As indicated on the Disconnect Schedule.

E. Listed UL 508 suitable for motor control.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install disconnect switches where indicated on the drawings.

B. Install fuses in fusible disconnect switches.

C. Provide adhesive label on inside door of each switch indicating UL fuse class and size for replacement.

1 **3.2 ADJUSTING**

2 A. Set field-adjustable circuit breaker trip ranges.

3 **END OF SECTION**

SECTION 26 28 21
CONTACTORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. General-purpose contactors
B. Lighting contactors
C. Enclosures

1.2 RELATED SECTIONS AND WORK

A. Refer to Lighting Contactor Schedule.

1.3 REFERENCES

A. ANSI/NEMA ICS 6 - Enclosures for Industrial Controls and Systems

B. NEMA ICS 2 - Industrial Control Devices, Controllers, and Assemblies

C. UL 508 - Industrial Control Equipment

1.4 SUBMITTALS

A. Submit shop drawings under provisions of Section 26 05 00.

B. Include outline drawings with dimensions, and equipment ratings for voltage, capacity, and poles.

C. Submit manufacturer's instructions under provisions of Section 26 05 00.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Schneider Electric
B. G.E.
C. ASCO

2.2 [C-1]: GENERAL-PURPOSE CONTACTORS

A. Contactors: NEMA ICS 2 and UL 508; electrically held, 2-wire control.

B. Coil Operating Voltage: 120 volts, 60 Hertz.

C. Size: NEMA ICS 2; size as indicated on the drawings.

D. Contacts: 600 volts, 60 Hertz.

E. Enclosure: ANSI/NEMA ICS 6; Type 1.

F. Provide solderless pressure wire terminals.

2.3 [LC-1]: LIGHTING CONTACTORS

A. Contactors: NEMA ICS 2 and UL 508; electrically held, 2-wire control.

B. Coil Operating Voltage: 120 volts, 60 Hertz.

C. Contacts: As indicated on the drawings.

D. Enclosure: ANSI/NEMA ICS 6; Type 1.

E. Provide solderless pressure wire terminals.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction boxes: and equipment enclosures.

E. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

END OF SECTION

SECTION 26 31 00
PHOTOVOLTAIC SYSTEM PERFORMANCE REQUIREMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section includes general performance requirements that apply to installing a roof mounted solar electric (PV) system for this project

B. Contractor is the Designer of Record for this system. Contractor is required to provide a Structural PE (Professional Engineer) Stamp for the structural design and an Electrical PE Stamp for the overall system design.

C. Both the structural and electrical stamps are to be provided from experienced PV designers with at least 5 similar completed projects.

D. Contractor is required to have experience with at least 5 similar completed PV projects.

E. Product specifications included in this section are the Basis for Design. Design substitutions shall meet the minimum performance requirements defined in this section. Contractor shall select number of inverters and perform string sizing.

F. Related Work and Requirements:

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

G. Incentive Paperwork:

1. Contractor to provide support with Owner's application for Focus on Energy incentives.

1.2 DEFINITIONS

A. MPPT: Maximum power point tracking.

B. STC: Standard test conditions, 1000 W/m2, 1.5 air mass, and 25°C cell temperature.

C. NABCEP: North American Board of Certified Energy Practitioners

D. PTC: PV USA Test Conditions, 1000 W/m2, 1.5 air mass, 20°C air temperature, and 1 meter/sec. wind speed.

E. Voc: Open circuit voltage

F. Isc: Short circuit current.

1.3 SUBMITTALS

A. Experience: Submit resumes for individuals involved with the design and construction of the PV System. Submit references and summaries of five similar projects that these individuals have completed.

B. Product Data: For each type of component indicated below. Include rated capacities, operating characteristics, and furnished specialties and accessories. All product data submittals shall be submitted for review by Owner prior to purchasing any materials or equipment.
   1. Solar panels
   2. Combiner boxes and fuses
   3. Grid tied inverters, including efficiency data.
   4. Solar panel structural system, including rail, clamps, and brackets.
   5. Manufacturer's installation instructions.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. All shop drawings shall be submitted for review by Owner prior to purchasing any materials or equipment.
   1. Dimensioned AutoCAD plan drawings of equipment including solar panel array, inverters, disconnects, combiner boxes, metering, and electrical routing.
   2. Provide AutoCAD drafted three-line wiring diagram of solar PV system indicating ratings of all panels and inverters, wire and conduit types and sizes, and disconnects.
   3. Wiring Diagrams: Power, signal, and control wiring.

D. Design Calculations
   1. The following design calculations shall be performed by Contractor and submitted for review by Owner prior to purchasing any materials or equipment.
      a. Electrical calculations, including string sizing, inverter selection, and voltage losses.
      b. Structural calculations, including rail spans, wind and snow loading, required ballast weights, and roof strength calculations.

E. Permitting and Agreements
   1. The following permits and agreements shall be prepared by Contractor on behalf of the Owner. All approved permits and agreements shall be submitted for review by Owner prior to purchasing any materials or equipment.
      a. Utility interconnection agreement
      b. Building permit
      c. Electrical permit

F. As built drawings:
   1. Dimensioned AutoCAD plan drawings of equipment including solar panel array, inverters, disconnects, combiner boxes, metering, and electrical routing.
   2. Provide AutoCAD drafted three-line diagram of solar PV system indicating ratings of all panels and inverters, wire and conduit types and sizes, and disconnects.

G. Field quality-control test reports.
   1. Include voltages and power output for each string. Measure and record solar intensity during testing. Include time, date, and weather conditions of test.

H. Operation and Maintenance Data: For panels, inverter, metering, and monitoring. In addition to items specified in Division 01 include the following:
   1. Instructions for operating equipment.
   2. Identification of operating limits which may result in hazardous or unsafe conditions.
   3. Document ratings of equipment and each major component.
   4. Technical Data Sheets.
   5. Wiring Diagrams.
   6. Parts list.

I. Warranty: Copies of all manufacturer's and installer's warranties.

1.4 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Maintenance Proximity: Not more than four hours' normal travel time from Installer's place of business to Project site.
   2. Installer must have PV Installer certification through NABCEP.

B. Source Limitations: Obtain panels from a single manufacturer, of a single type and rating. Obtain inverters from a single manufacturer, of a single type and a single rating.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with NFPA 70 and all applicable state and local codes

1.5 COORDINATION

A. Coordinate metering and interconnection agreement with electric utility. Contractor shall pay all interconnection fees including the application review fee, engineering review fee, and distribution system study fee. Contractor shall submit all required forms to utility.

1.6 WARRANTY

A. Installer must provide a two year installation warranty covering any defects of the installation.

B. Panel Warranty Period:

1. 5 years workmanship warranty.
2. 10 year 90% linear power output warranty.
3. 25 year 80% linear power output warranty.

C. Inverter Warranty Period: 15 year warranty.

PART 2 - PRODUCTS

2.1 SOLAR PANELS

A. Available Manufacturers: Subject to compliance with performance requirements, manufacturers offering products that may be incorporated into the Work include:

1. Heliene
2. Solarworld
3. LG
4. Hanwha Q-cells
5. Canadian Solar

B. If an alternate product is proposed, bid is to document how the proposed solution is more cost effective to the owner. Follow substitution request procedure per 01 25 13.

C. Capacities and Characteristics:

1. All panels shall be of a single type from a single manufacturer.
2. Power Output Ratings: STC rated power of between 270 and 300 watts.
3. DC Array size of 50.05 to 50.40 kW
4. AC Energy Produced between 59,646 and 60,065 kWh/yr based on the following assumptions:
   a. http://pvwatts.nrel.gov/pvwatts.php (PV Watts version 1)
   b. Module Type: Standard
   c. Array Type: Fixed (roof mount)
   d. System Losses: 14%
   e. Tilt: 5 degrees
   f. Azimuth: 180 degrees
   g. DC to AC Size Ratio: 1.1
   h. Inverter Efficiency: 96%
   i. Ground Coverage Ratio: 0.4
5. Power tolerance of less than 5% variation (maximum minus minimum). Minimum tolerance of -0%.
6. Manufactured in the U.S., Mexico or Canada
7. Nameplates: To identify electrical characteristics, manufacturer's name and address, and model and serial number of component.
8. Module efficiency: minimum 17.00%

D. Materials and construction

1. Monocrystalline or Polycrystalline
2. Junction box with bypass diodes.
3. Output Connections: Factory wired separate positive and negative leads sized per division 26 wire requirements with locking quick disconnects, rated for use in direct sunlight. Shall meet all requirements of NEC article 690.33.
4. Anodized aluminum frame with drainage holes and grounding holes.
5. Operating temperature range of -40°C to +85°C.
6. Withstand 1" diameter hail at 50 mph without damage.
7. Load rated at 5400 Pa (113 psf) when used with two rail system.

2.2 INVERTERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include:
   1. SMA
   2. Fronius
   3. Solar Edge with P600 Optimizers (1 Optimizer per 2 panels) -Basis of Design

B. If an alternate product is proposed, bid is to document how the proposed solution is more cost effective to the owner. Follow substitution request procedure per 01 25 13.

C. Standards
   1. IEEE 1547
   2. UL 1741 – anti-islanding.

D. Electrical characteristics
   1. AC kW rating: Minimum DC-to-AC ratio of 1.2
      a. Provide up to four (4) inverters rated for a total of 50 kW nominal DC input.
      b. The basis of design is three (3) inverters. Systems with an additional inverter shall include providing an additional circuit breaker, disconnect, and feeder from main service panel to inverter to match other inverters.
   2. Output voltage: 208VAC (-12%, +10%), 3 phase.
   3. Frequency: 60 Hz sine wave
   4. Input voltage: Coordinated with solar array.
   5. Max Voc: Coordinated with solar array.
   6. Max DC current: Coordinated with solar array.
   7. Startup voltage: Coordinated with solar array.
   8. Output power factor: Unity
   9. DC to AC conversion efficiency:
      a. 97.5% CEC rated efficiency
   10. A/C and D/C rapid shutdown compliant with NEC 2017

E. Features
   1. Transformerless design.
   2. Forward facing DC disconnect
   3. DC side ground fault protection.
   4. Inverter must limit power output to nameplate value. If connected to an array capable of producing more than the inverter's capacity, the inverter must limit the power without damage.
   5. Maximum power point tracking over the range of voltages of the array, at the ambient temperatures of the site.
   6. User navigable display.
   7. LED status lights on enclosure.
   8. Communication port for diagnostics and communication port for communication with multiple inverters and internet interface device.
   9. NEMA 3R enclosure

2.3 PV WIRING

A. Type PV-WIRE, #10AWG, from array to combiner box, and where used as a jumper for connection between panels.

B. UV-Stabilized Cable Ties:
   1. Fungus inert, designed for continuous exposure to exterior sunlight, self extinguishing, one piece, self locking, Type 6/6 nylon.
   2. Minimum Width: 3/16 inch (5 mm).
   3. Tensile Strength at 73 °F (23 °C), According to ASTM D 638: 12,000 psi (82.7 MPa).
   4. Temperature Range: -40 to +185 °F (-40 to +85 °C).
   5. Color: Black.

C. Ampacity of PV source circuits shall be a minimum of 156% of the sum of parallel strings short circuit currents.
   1. Shall be sized to limit voltage drop to 0.5% from array to inverter during full production at MPPT voltage at maximum ambient temperature.
   2. Shall be in metallic conduit from combiner box, if installed, to inverter.

2.4 COMBINER BOX

A. If needed, Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include:
   1. Blue Oak
   2. SMA
   3. MidNite solar

B. If an alternate product is proposed, bid is to document how the proposed solution is more cost effective to the owner. Follow substitution request procedure per 01 25 13.

C. Capacities and Characteristics:
   1. DC current and voltage ratings coordinated with array.
   2. Positive and negative combiner blocks.
      a. Number of poles coordinated with array.
   3. DC voltage fuses in fingersafe fuse holder.

D. Materials and construction
   1. Powder coated steel, NEMA 3R enclosure.
   2. Knockouts
   3. Stainless steel hardware.

2.5 RACKING & ROOF ATTACHMENT & ROOF PENETRATIONS

A. Tilt Angle of Panels: 5 degrees from horizontal (flat to roof)

B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include:
   1. Products for systems on low slope standing seam metal roofs and canopy superstructre :
      a. Schletter
      b. IronRidge

2.6 METERING

A. Refer to Division 26 specifications.

2.7 INTERNET BASED MONITORING

A. Provide standard package from inverter manufacturer and connect to the City Network. Coordinate with Owner. Contractor is required to test monitoring to confirm it is functioning.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of electrical connections. Verify actual locations of connections before panel installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 ARRAY REQUIREMENTS

A. Install panels on racking designed for solar (PV) panels.

B. Coordinate installation with roof shop drawings.

C. Structural Performance: Installation shall withstand all local wind and snow loads, and all local building department requirements.

D. If applicable, slip sheet is to be used between ballasted racking and roof membrane

E. All fastening hardware must be stainless steel.

F. All materials must be metallurgically compatible where different materials are in contact with each other.

G. Roof penetrations shall be made watertight using methods that are standard to the roofing industry, are approved by the roofing manufacturer, and that protect the warranty of the roof.

H. The panels shall be connected in arrays with the following characteristics:
   1. Total DC peak STC rated power of all panels in the array shall be minimum 50.05 kW. The panels shall be divided into even arrays between the inverters.
   2. The panels shall be installed only in the area outlined on the architectural roof drawing.
   3. If an alternate layout is proposed, bid is to document how the proposed solution is more cost effective to the owner. Follow substitution request procedure per 01 25 13.
   4. If needed, each array shall be provided with a combiner box.
   5. The panels shall be installed with long axis as shown on architectural roof drawing.

6. PV panel cables may be installed exposed where routed directly behind panels, but all cables shall be installed in a section of conduit where crossing part of the roof not under a panel. Conduit running across roof shall be supported on roof using Cooper B-Line Dura-Blok or equivalent.
7. All PV panel cables shall be installed in a neat and workmanship like manner. Excess wire shall be coiled and bundled neatly and supported securely in an area where they are not subject to environmental degradation, such as from wind, sun, and animals. Attach PV panel cables to racking with zip-ties listed for use in direct sunlight.
8. Panels shall be connected in series and parallel to match voltage and current ratings of inverter, across all ambient temperatures common to site (-25°C to 40°C).
    a. Open circuit voltage of array on coldest day of year in full sunlight shall not exceed maximum operating voltage rating of inverter, panels, or any other equipment.
    b. Open circuit voltage on warmest day of year in morning sunlight conditions (200W/m2 irradiance) shall exceed inverter startup voltage. Voltage under operating MPPT conditions, minus any voltage drop over conductors, shall exceed minimum inverter input voltage.
    c. Available short circuit current multiplied by 1.25 shall not exceed ratings for the inverter or any panels.
    d. All series strings of panels shall have same performance characteristics.

3.3 ELECTRICAL INSTALLATION

A. Ground equipment according to Division 26
    1. Size grounding conductors per NEC articles 250 and 690.
    2. All conductive equipment enclosures must be grounded.
    3. All panel frames must be grounded.
        a. The removal of any panel shall not interrupt a grounded conductor to another photovoltaic source circuit.

B. Install wiring, combiner boxes, conduit, disconnects, inverter, web based monitoring hardware, sensors and other equipment according to Division 26.

C. Connect wiring according to Division 26.

3.4 IDENTIFICATION

A. Identify and label system components according to Division 26.
    1. Provide a unique label for each inverter, PV output circuit, combiner box, PV Source circuit, and panel. Labeling shall match labeling shown on as-built diagram and plan provided by contractor.

B. Provide all labeling required by NEC article 690, including, but not limited to:
    1. Label disconnects capable of being energized from both directions as such.
    2. Provide plaque at utility service disconnect per article 690.56B. Field verify exact location.
    3. Label each photovoltaic disconnecting means per NEC article 690.53.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections as indicated below and prepare test reports. Correct any deficiencies.
    1. Visually inspect all connections.
    2. Visually inspect all supports.
    3. Measure Voc of each individual string of panels under full sunlight.
        a. Verify Voc of all strings are balanced.
        b. Verify measured Voc against calculated Voc for the ambient temperature. Extrapolate Voc to temperatures expected at site, and verify they are within inverters ratings.
    4. Measure Isc of each string of panels.
    5. Verify correct operation of inverter.
    6. Verify correct operation of complete system.
    7. Replace any defective panels. Panels shall be replaced at contractor's expense.

3.6 DEMONSTRATION

A. Simulate power outage by interrupting normal source, and demonstrate that system disconnects from utility.

B. Provide owner's maintenance personnel with minimum two hour training session and in compliance with Div 1 Training Requirements.
    1. Provide training on function of each piece of equipment.

2. Provide training on maintaining the system.
3. Explain means of disconnecting the system, and principals of operation and safety.

END OF SECTION

SECTION 26 43 00
SURGE PROTECTION DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes materials and installation requirements for low voltage surge protection devices (SPD) for the protection of all AC electrical circuits. SPD equipment to be installed at designated service entrance equipment, distribution panels, electronic equipment, and receptacle devices.

1.2 QUALITY ASSURANCE

A. The specified unit shall be designed, manufactured, tested and installed in compliance with the above references. The unit shall be "Listed by Underwriters Laboratories" to UL 1449.

B. Each unit shall be designed and manufactured by a qualified manufacturer of power conditioning equipment. The qualified manufacturer must have been engaged in the design and manufacturer of such products for a minimum of five years.

1.3 REFERENCES

A. ANSI/IEEE C62.33 – IEEE Guide on Testing of MOV components

B. ANSI/IEEE C62.35 – IEEE Guide on Testing of SAD components

C. ANSI/IEEE C62.41 - IEEE Recommended Practice on Surge Voltage in Low Voltage AC Power Circuits

D. ANSI/IEEE C62.45 - IEEE Guide on Surge Testing for Equipment Connected to Low Voltage AC Power Circuits

E. ANSI/UL 1449 Third Edition (Version 3.0) - UL Standard for Safety for Surge Protective Devices

F. CBEMA – Computer Business Equipment Manufacturers Association

G. IEC 664 – International Engineering Consortium, Standard for Clamping Voltage

H. National Electrical Code 285 - Surge Protection Devices

I. NFPA 70 - National Electrical Code

J. UL 67 – Listed for Internal Panelboard Transient Voltage Surge Suppressors

K. UL 96A – Devices listed as approved for secondary surge arrestors (VZCA)

L. UL 248-1 - Fusing

M. UL 1283 – Electromagnetic Interference Filters, Fifth Edition

1.4 SUBMITTALS

A. Shop Drawings: Should include device dimensions, mounting requirements including wire size and over-current protection device rating, nameplate nomenclature, electrical ratings, short circuit current rating, and test results as indicated below under "Testing, Warranty and Life Expectancy" as provided by an independent test lab or a UL certified test lab for the category(ies) of suppression device(s) specified using the appropriate IEEE test wave. Product data sheets with installation instructions for each size and type of device are required. Shop drawings submitted without the testing data as required by section this section will be rejected.

B. Fuse information: Provide fuse information if required for operation. Include size, manufacturer, time-current chart responses to UL 1449 testing requirements, maximum surge protection capability per mode and phase as limited by the fuse, and verification of repetitive surge protection device operation without system degeneration greater than 10%.

1.5 SPARE PARTS

A. Fuses: Furnish to the Owner 3 spare fuses of each type and rating installed.

1.6 TESTING, WARRANTY AND LIFE EXPECTANCY

A. Manufacturer must provide independent testing on repetitive capability and maximum surge current rating of service entrance suppressor units. This shall be performed at a nationally recognized lab not affiliated with the manufacturer.

1. Single pulse surge current capacity: Single pulse surge current tested in a mode at rated surge currents.

2. Single pulse surge current capacity test: An initial UL 1449 defined 1.2 x 50µs, 6000V open circuit voltage waveform and an 8 x 20µs, 500A and 3kA short circuit current waveform shall be applied to benchmark the unit's suppression voltage (VPR).

3. A single 8 x 20µs waveform pulse of maximum rated surge current per mode shall then be applied. To complete the test, another UL 1449 surge shall be applied to verify the unit's survival. Survival is achieved if the suppression voltage measured from the two UL1449 surges does not vary by more than 10%.

B. Minimum Repetitive Surge Current Capacity:

1. Service entrance suppressor units should be tested repetitively at an independent lab to verify repetitive capacity.

2. Minimum Repetitive Surge Current Capacity Test:

a. An initial UL 1449 surge defined as 1.2 x 50µs, 6000V open circuit voltage waveform and an 8 x 20µs, 500A and 3kA short circuit current waveform shall be applied to benchmark the unit's suppression voltage.

b. A repetitive number of ANSI/IEEE C62.41.2-2002 (Category C3) surges, defined as a 1.2 x 50µs 10kV or 20kV open circuit voltage waveform and an 8 x 20µs 10,000A short circuit current waveform, shall then be applied at one-minute intervals.

c. To complete the test, another UL 1449 surge shall be applied to verify the unit's survival.

3. Survival is achieved if the suppression voltage (VPR) does not vary by more than 10%.

4. Proof of such testing shall be the test log generated by the surge generator.

C. Provide UL 1449 classification white sheet pages indicating the VPR (voltage protection rating) for each SPD unit submitted for this product using the 6kV/3kA combination wave surge.

D. Warranty: Ten (10) years. Includes workmanship, installation and programming.

PART 2 - PRODUCTS

2.1 DESCRIPTION

A. General: The unit shall provide transient voltage suppression, surge current diversion and high-frequency noise attenuation, when connected in parallel to the facilities distribution system. The unit MCOV shall not be less than 115% of the nominal system voltage. Operating frequency shall be for a 60 Hz system. The unit shall provide protection in all normal modes for "wye" and "delta" systems. The short circuit current rating shall be the larger of the listed value on the drawings or as required by the equipment protected.

2.2 RATINGS

A. **[SPD-1]:** Service Entrance Suppressors:

1. For 120/208 volt, 3 phase, 4 wire, type 2, category C3 unit.

    a. Surge current capacity: 100,000/200,000 amps per protection mode/phase
    b. Nominal Discharge Current: 20 kA.
    c. Mounting: Refer to the drawings.
    d. Voltage Protection Rating: Refer to requirements below.
    e. Components: Minimum component size of 20mm metal oxide varistors (MOV).
    f. Disconnect: Surge-rated disconnect with 200,000 SCCR.

2. Approved Manufacturers:

    a. Square D Surelogic EMA Series
    b. Siemens TPS3 Series
    c. Cutler Hammer SPD Series
    d. Current Technology Current Guard Plus
    e. Emerson Network Power 560 Series
    f. LEA International LSS Series

B. **[SPD-2]:** Secondary Distribution Suppressors:

1. For 120/208 volt, 3 phase, 4 wire, type 2, category B3/C1 unit.

    a. Surge current capacity: 60,000/120,000 amps per protection mode/phase
    b. Nominal Discharge Current (I_N): 20 kA.
    c. Mounting: Refer to the drawings.
    d. Voltage Protection Rating: Refer to requirements below.
    e. Components: Minimum component size of 20mm metal oxide varistors (MOV).

2. Approved Manufacturers:

    a. Square D Surgelogic EMA Series
    b. Siemens/APT TPS3 Series
    c. Cutler Hammer SPD Series
    d. Current Technology Current Guard Plus
    e. Emerson Network Power 510 Series
    f. LEA International CFS Series

C. Voltage Protection Rating:

1. Protection modes and UL 1449 voltage protection rating for surge suppression units per each mode (L-N, L-L, L-G, and N-G as appropriate).

    a. 120/208 Volt, 3 phase, 4 wire. 700 Volt L-N, N-G, 800 Volt L-G and 1200 Volt L-L

D. Critical Load Protection – Fixed Equipment:

1. For 120 volt, 1 phase, 3 wire, type 3, category A3 unit.

a. Surge current capacity (I_N): 15,000/30,000 amps per protection mode/phase

b. Mounting: External, NEMA 12 enclosure

c. Components: Nonmodular units composed of 20mm Metal Oxide Varistors (MOV). Series inductors, SAD, or selenium cells may be used in addition to MOVs.

d. Protection modes and UL 1449 clamping voltage: 475 Volt L-N, L-G, and N-G.

E. Receptacles:

1. For 120 volt, 1 phase, 3 wire, type 3, category A3 unit.

a. Surge current capacity (I_N): 12,000 amps per protection mode.

b. Components: 20mm MOV

c. Maximum Continuous Operating Voltage: 150 Volts

2. Refer to Specification Section 26 27 26 for additional receptacle construction information.

F. EMI/RFI Noise Rejection or Filtering:

1. Each unit shall include a UL1283 first order, high-frequency filter for noise filtering between 10 KHz and 100 MHz.

G. Indication:

1. Each unit shall include solid-state indicators with externally mounted LED visual status indicators that indicate on-line status of each protection mode of the unit.

2. Provide each service entrance secondary distribution type unit(s) with a transient counter.

3. Each unit shall contain form “C” contacts for remote indication of an alarm status.

H. Fuses:

1. Use fuses recommended by the manufacturer to satisfy repetitive UL 1449 operation of the surge suppression unit.

2. Fuses shall be rated 200, 000 AIC minimum interrupting capacity.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine equipment for size and type of surge protection device to be used to ensure physical compatibility.

B. Inspect surge protection device for any signs of physical damage due to shipping or handling before installing surge protection device.

3.2 INSTALLATION

A. Mounting Location:

1. The unit shall be installed as close as practical to the panel secondary lugs in accordance with applicable national/Local Electrical Codes and the manufacturer's recommended installation instructions. Connect the unit to the panel using a conduit nipple. Flush mount the unit in the front of the switchboard. Mount unit directly across from the breaker or disconnect serving it.

2. If internal surge protection device is specified, device shall be installed in a barrier compartment isolated from other components.

B. Connections:

1. Contractor shall provide wire and circuit breakers sized per the approved manufacturer's requirements. Maximum lead length from protected bus to surge protection device shall be per manufacturer's requirements, but no greater than 5'-0".

2. The surge protection unit shall be isolatable from the electrical distribution system via 3 pole circuit breaker mounted in the switchboard/panelboard. Single phase 120 volt units shall be hardwired without a disconnecting means.

3. Neutral and ground shall not be bonded together at secondary panelboard locations.

C. Additional Locations: Critical Load Protection – Fixed Equipment (120 Vac):

1. Install an A3 hard-wired surge protection device between each of the following equipment items and its power supply conductors.

   a. Fire alarm master panel
   b. Phone switch
   c. Intercom master
   d. Building management system master
   e. Security system master
   f. Telephone switch
   g. TV head

D. General:

1. Check unit for proper operation of protection and indication under start-up.

2. Check unit to ensure all MOVs for each mode of protection are operational. Verify integral fuse links are operational and have not melted.

3. Surge suppression devices shall not be installed ahead of the main service disconnect(s).

4. Install fuses in all fuse holders and fused disconnects internal to the surge protection unit. Use fuses recommended by the manufacturer to satisfy repetitive UL 1449 operation of the surge suppression unit. External fusing of the surge protection device is not allowed.

5. Coordinate location of surge protection device to allow adequate clearances for maintenance.

END OF SECTION

SECTION 26 51 00
LIGHTING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Interior luminaires and accessories
B. Exterior luminaires and accessories
C. Lamps
D. Ballasts
E. Poles

1.2 REFERENCES

A. ANSI C78.377-2008 – Specifications for the Chromaticity of Solid State Lighting Products

B. ANSI C82.77-2002 – Standard for Harmonic Emission Limits and Related Power Quality Requirements for Lighting Equipment

C. IEEE C2 - National Electrical Safety Code

D. Project site classification as defined in IESNA RP-33 LZ2

1.3 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

B. Submit product data sheets for luminaires, lamps, drivers and poles. Include complete product model number with all options as specified. Submittal shall be arranged with fixtures listed in ascending order, and with each luminaire's associated lamp, ballast, driver, or pole information following luminaire's product data. Failure to organize submittal in this manner will result in the submittal being rejected.

C. Submit lens product data, dimensions and weights if not included in product data sheet submittal.

D. Include outline drawings, support points, weights, and accessory information for each luminaire type.

E. Submit utility rebate forms, where offered at project location, with rebate items completed.

F. LED luminaire submittals shall include photometric report per IESNA LM-79-08 for the latest generation system being furnished, including independent testing laboratory name, report number, date, luminaire model number, input wattage, luminaire, and light source specifications. Manufacturer origin of LED chipset and driver shall be submitted.

G. For all LED luminaires specified as dimmer controlled, submit dimmer device data that is approved by manufacturer of submitted luminaire and that Contractor proposes to furnish and install. Contractor is responsible for verifying that installed dimming controls are compatible with and approved by the luminaire manufacturer.

H. LEED Requirements:

1. Light Pollution Reduction:

a. Exterior Luminaires: Submit manufacturer data showing percentage of light lumens emitted at or above 90° from nadir for each luminaire type.

1.4 EXTRA STOCK

A. Provide extra stock under provisions of Section 26 05 00.

B. Fixtures: One (1) fixture of each type listed in the Luminaire Schedule.

C. LED Light Engines or Modules: Three (3) percent of quantity installed, minimum of one (1) of each size and type.

D. Lenses: Three (3) percent of quantity installed, minimum of one (1) of each size and type.

E. LED replacement lamps: Three (3) percent of quantity installed, minimum of one (5) of each size and type.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site. Store and protect under provisions of Section 26 05 00.

B. Protect luminaire finishes, lenses, and trims from damage during storage and installation. Do not remove protective films until construction cleanup within each area is complete.

C. Handle site lighting poles carefully to prevent breakage and damage to finish.

1.6 WARRANTY

A. Light emitting diode (LED) light engines and drivers shall have a ten-year warranty from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 INTERIOR LUMINAIRES AND ACCESSORIES - GENERAL

A. Lensed Troffers: Provide hinged frames with latches and 0.125 inch thick virgin acrylic lenses. Prismatic lenses shall have depth of no less than 0.080", KSH12 or equal. Other lenses as scheduled.

B. Recessed Luminaires: Confirm ceiling and wall type and furnish trim and accessories necessary to permit proper installation in each system. Where fire-rated ceiling or wall assemblies are specified, furnish and install listed enclosures around luminaires that maintain the system rating.

C. Suspended Luminaires: Coordinate power feed and suspension canopies with ceiling type and architectural RCP for proper fit and location. Ensure finished installations are plumb and level at elevations specified.

D. Exit Signs: Stencil face, 6 inch high letters, directional arrows as indicated, universal mounting type as indicated on the drawings.

E. Self-Powered Emergency Lighting Units: One-piece, self-contained unit with sealed, maintenance-free nickel cadmium battery, automatic charger and electronic circuitry. Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.

F. Painted reflector surfaces shall have a minimum reflectance of 90%.

G. All painted components shall be painted after fabrication.

2.2 EXTERIOR LUMINAIRES AND ACCESSORIES - GENERAL

A. Listed for wet or damp location as scheduled. Fountain and pool luminaires shall be listed for submersible location to meet depth specified.

B. Provide low temperature ballasts or LED drivers, with reliable starting to -20°F.

C. In-grade luminaires shall have lamp/optic separation to prevent surface temperature from exceeding 115°F. Compartment separation of wire entry and control gear/lamp chamber.

2.3 LIGHT EMITTING DIODE (LED) LUMINAIRE SYSTEMS

A. Light emitting diodes used in interior applications shall have a minimum color rendering index (CRI) of 80. Light emitting diodes used in exterior applications shall have a minimum color rendering index (CRI) of 70. Color temperature of the luminaires shall be as noted on the luminaire schedule.

B. LED chip arrays specified as color changing shall have chip colors as noted on the luminaire schedule.

C. LED chips shall be wired so that failure of one chip does not prohibit operation of the remainder of the chip array.

D. LED Driver:

1. Solid state driver with integral heat sink. Driver shall have overheat, short-circuit and overload protection, power factor 0.90 or above and maximum total harmonic distortion of 20%. Surge suppression device for all exterior luminaires.

2. Drivers shall have dimming capabilities as outlined in the luminaire schedule for each luminaire type.

3. Driver shall have a minimum of 50,000 hours rated life.

2.4 ACCEPTABLE MANUFACTURERS - POLES

A. Manufacturer of Luminaire.
B. Valmont Poles.
C. U. S. Pole Company.
D. KW Industries

2.5 LIGHTING POLES

A. Metal Poles: Size and type as noted on drawings.

B. Wind Load: 100 MPH velocity, with 1.3 gust factor with luminaires and brackets mounted.

C. Hand Hole: 2 x 4 inches with removable weatherproof cover installed at manufacturer's standard location. Provide matching gasketed cover plate.

D. Pole Top: Provide slipfitter.

E. Anchor Bolts: As recommended by pole manufacturer. Provide template, flat washers, lock washers, and hex nuts for each pole. Grout between anchor plate and concrete base with non-shrink grout after pole is plumbed.

F. Vibration Damper: Canister or snake type second mode vibration damper internal to the pole as recommended by pole manufacturer. Provide additional pole top damper for first mode vibration on single-head poles where recommended by manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Securely fasten luminaires to the listed and labeled ceiling framing member by mechanical means such as bolts, screws, rivets or listed clips identified for use with the type of ceiling framing members. If ceiling framing is not listed for luminaire size or weight, support luminaires independent of ceiling grid with a minimum of two (2) #12 gauge wires located on diagonal corners.

B. Install recessed flanged luminaires to permit removal from below. Use manufacturer-supplied plaster frames and swing gate supports. Support luminaires independent of ceiling with a minimum of two (2) #12 gauge wires located on diagonal corners.

C. Support surface-mounted luminaires directly from building structure. Install luminaires larger than eight square feet (8 ft^2) or weighing more than 30 pounds independent of ceiling framing.

D. Support suspended or pendant mounted luminaires independent of ceiling grid with a minimum of two #12 gauge wires. Suspension assembly and anchors shall be capable of supporting 300 pounds dead load at each suspension point.

E. Install lamps in lamp holders of luminaires.

F. Adjust aimable luminaires to obtain lighting levels on objects and areas as directed to obtain desired lighting levels.

G. Parabolic louvers and other optical accessories shall remain in protective wraps or films until construction in area is complete and area has been cleaned.

H. Industrial Pendant Luminaires: Use hangers rated 500 pounds minimum or provide safety chain between ballast and structure. Provide safety chain between reflector and ballast.

I. Luminaire Pole Bases: Sized and constructed as indicated on the drawings. Project anchor bolts 2 inches minimum above base. Install poles plumb with double nuts for adjustment. Grout around pole anchor base.

J. Use belt slings or non-chafing ropes to raise and set pre-finished luminaire poles.

3.2 RELAMPING

A. Replace failed lamps at completion of work.

3.3 ADJUSTING AND CLEANING

A. Align luminaires and clean lenses and diffusers at completion of work. Clean paint splatters, dirt, and debris from installed luminaires.

B. Touch up luminaire and pole finish at completion of work.

3.4 LUMINAIRE SCHEDULE

A. As shown on the drawings.

END OF SECTION

SECTION 26 52 00
EMERGENCY LIGHTING EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Emergency lighting units with self-test capability
B. Emergency exit signs with self-test capability
C. Emergency fluorescent lamp power supplies
D. Emergency inverters for LED
E. Emergency transfer devices

1.2 REFERENCES

A. FS W-L-305 - Light Set, General Illumination (Emergency or Auxiliary)

B. NFPA 101 - Code for Safety to Life from Fire in Buildings and Structures

C. UL 924 – Emergency Lighting and Power Equipment

1.3 SUBMITTALS

A. Submit shop drawings under provisions of Section 26 05 00.

B. Provide product data on emergency lighting units, exit signs, emergency inverters, and emergency fluorescent lamp power supply units.

1.4 REGULATORY REQUIREMENTS

A. Conform to NFPA 101 for installation requirements.

PART 2 - PRODUCTS

2.1 INCANDESCENT EMERGENCY LIGHTING UNITS

A. Emergency Lighting Unit: Self-contained unit with rechargeable storage batteries, charger, and lamps.

B. Battery: Maintenance free lead calcium type, with 1.5 hour capacity to supply the connected lamp load.

C. Charger: Dual-rate solid state charger, capable of maintaining the battery in a full-charge state during normal conditions, and capable of recharging discharged battery to full charged within 168 hours. Low voltage disconnect to prevent deep discharge of battery.

D. Lamps: As scheduled on luminaire schedule.

E. Remote Lamps: Match lamps on unit.

F. Indicators: Provide lamps to indicate AC ON and RECHARGING.

G. Provide test switch to transfer unit from normal supply to battery supply.

H. Electrical Connection: Knockout for conduit connection.

I. Unit Voltage: 120 volts, AC.

J. Unit shall be self-diagnostic with continuous monitoring of charger performance and battery voltage. Any malfunction of battery, charger, transfer circuit or emergency lamps shall be detected and visually indicated.

K. Unit shall be programmed to exercise the battery and test emergency operation by performing a five minute discharge/diagnostic cycle every 6 months. A manual test switch shall allow a five minute discharge/diagnostic test at any time.

L. Warranty: Emergency lighting unit shall have a full three (3) year, non-prorated warranty.

2.2 SELF-CONTAINED EMERGENCY POWER EXIT SIGNS

A. Type: Exit signs with integral battery-operated emergency power supply, including power failure relay, test switch, AC ON pilot light, battery, and fully-automatic two-rate charger.

B. Battery: Sealed lead acid or lead calcium cell, requiring no maintenance or replacement for 10 years under normal conditions.

C. Directional Indicators: The directional indicator for exit signage shall be of a chevron type meeting all requirements of NFPA 101.

D. Unit shall be self-diagnostic with continuous monitoring of charger performance and battery voltage. Any malfunction of battery, charger, transfer circuit or emergency lamps shall be detected and visually indicated.

E. Unit shall be programmed to exercise the battery and test emergency operation by performing a five minute discharge/diagnostic cycle every 6 months. A manual test switch shall allow a five minute discharge/diagnostic test at any time.

2.3 ACCEPTABLE MANUFACTURERS - EMERGENCY BALLASTS AND INVERTERS

A. Philips/Bodine.
B. Dual-Lite.
C. Iota.

2.4 EMERGENCY INVERTER – LED LAMPS UP TO 20 WATTS

A. Unit: Self-contained, with automatic transfer to battery supply on loss of normal power, UL 924 listed for factory or field installation in indoor and damp locations.

B. Battery: Sealed, high temperature, maintenance free, nickel cadmium battery with capacity to provide 90 minutes of emergency operation, with 24-hour recharge time, seven (7) year minimum battery life expectancy.

C. Features: Integral battery charger with LED charging indicator light, test switch, electronic circuitry for use with ballasts, and LED drivers. Output of inverter shall be sinusoidal with solid-state low voltage disconnect circuit.

D. Inverter to be mounted remote and adjacent to luminaire shown on drawings. Inverter to be accessible from below ceiling through luminaire opening.

E. Charging indicator LED and test switch to be mounted in remote test/monitor plate provided with inverter.

F. Inverter capable of operating a switched, dimmed or unswitched luminaire up to 20 watts with full lumen output.

G. Warranty: Emergency inverter shall have a full five (5) year, non-prorated warranty.

2.5 EMERGENCY LED DRIVER

A. Unit: Self-contained, with automatic transfer to battery supply on loss of normal power, UL 924 listed for factory or field installation in indoor and damp locations.

B. Battery: Sealed, high temperature, maintenance free, nickel cadmium battery with capacity to provide 90 minutes of emergency operation, with 24-hour recharge time, seven (7) year minimum battery life expectancy.

C. Features: Integral battery charger with LED charging indicator light, test switch, and electronic circuitry for use with LED drivers.

D. Inverter to be mounted remote and adjacent to luminaire shown on drawings. Inverter to be accessible from below ceiling through luminaire opening.

E. Charging indicator LED and test switch to be mounted in remote test/monitor plate.

F. Inverter capable of operating a switched, dimmed, or unswitched luminaire up to 7 watts at a rated current of 270mA.

G. Warranty: Emergency inverter shall have a full five (5) year, non-prorated warranty.

2.6 EMERGENCY TRANSFER DEVICES

A. Loss of power on normal circuit shall switch load to emergency power source.

B. Provide suitable NEMA 1 enclosure and mounting per manufacturer specification.

C. **[ETD]**: Emergency Lighting Control Override - Single Luminaire:

1. Rated 2 amps at 120 volt incandescent and 10 amps at 277 volt fluorescent.

2. Approved Manufacturers: Bodine GTD, Iota ETS, Watt Stopper ELCU-100.

D. **[ETD-2]**: Emergency Lighting Control Override - Branch Loads:

1. Rated 1000 watts at 120 volt incandescent and 20 amp at 277 volt fluorescent.

2. Approved Manufacturers: Bodine GTD20, Chloride Lightstar, Dual-Lite ATSD, Nine24 BLTC, Highlites HEPC.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units plumb and level.

B. Aim directional lampheads as directed.

C. Test emergency lighting equipment for 60 minutes to determine proper operation, prior to substantial completion. Provide typewritten periodic test log form to Owner's representative. Explain and instruct Owner's representative of requirements for testing and maintenance.

END OF SECTION

SECTION 26 52 15
EMERGENCY POWER SUPPLY

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Emergency power supply **[LIV-1]**

1.2 QUALITY ASSURANCE

A. Manufacturer: Company specializing in battery-inverter power supplies with three (3) years documented experience.

1.3 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

B. Indicate unit ratings, dimensions, and finishes. Include performance data for batteries.

C. Submit manufacturer's installation instructions under provisions of Section 26 05 00.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 26 05 00.

B. Store and protect products under provisions of Section 26 05 00.

1.5 REGULATORY REQUIREMENTS

A. Listed to UL 924.Emergency Lighting and Power Equipment.

B. Compliance with NFPA 101 Life Safety Code.

1.6 SYSTEM DESCRIPTION

A. System Configuration: Emergency power supply consisting of rectifier/charger unit, storage battery, and solid state inverter in one or several enclosures.

B. Operating Sequence: When utility power is available, it supplies load through transfer switch, and battery charger maintains battery charge. If utility fails, load is transferred to battery-powered inverter. When utility is restored, load is retransferred and battery charger restores battery charge.

1.7 OPERATION AND MAINTENANCE DATA

A. Submit data under provisions of Section 26 05 00.

B. Include battery maintenance and unit testing procedures.

1.8 WARRANTY

A. Warranty: The manufacturer shall warrant the inverter for a period of 12 months after Substantial Completion. Provide 10 year pro-rated warranty on battery under provisions of Section 26 05 00, pro-rated after first year on straight line basis.

B. Include coverage of travel, labor, parts and service.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Dual-Lite - Hubbell Lighting Inc.
B. Philips Chloride.
C. Lithonia Lighting EAC Series.
D. Perfect Power Systems.

2.2 EMERGENCY LIGHTING INVERTER [LIV-1]

A. Inverter: Uninterruptible double-conversion IGBT type. Unit suitable for operating HID lamps or LED drivers without extinguishing lamp on transfer.

B. Input Voltage: 208 volts, 60 Hertz, three phase +/-10%.

C. Output Power: 4800 VA at 0.8 power factor.

D. Output Voltage: 120/208 volts ± 2 percent, three phase 4 wire.

E. Inverter Output Frequency: 60 Hertz ± 1 percent.

F. Maximum Recharge Time: 12 hours following 1.5 hour discharge.

G. Total Harmonic Distortion: Less than 5 percent at full linear load.

H. Battery Operating Time: 1.5 hours at full load and within output voltage limits.

I. Battery: Lead calcium, sealed maintenance-free type. Low voltage battery disconnect protects the battery from “deep discharge” during prolonged power outages.

J. Charger: Dual rate, designed to maintain battery in full-charge condition during normal conditions.

K. Self-test/Self-diagnostics: Automatically perform and log monthly1 minute test and annual 60 minute test.

L. Accessories: Provisions for remote monitoring via RS232 interface.

2.3 REMOTE STATUS MONITORING

A. Indicators: Common derangement lamp and audible tone. Include silence switch arranged for ring back feature.

B. Enclosure: Surface mounted with factory finish.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units plumb and level with required clearances.

B. Provide interconnection between cabinets.

1 **3.2 MANUFACTURER'S FIELD SERVICES**

2 A. Provide manufacturer's field services under provisions of Section 26 05 00.

3 B. Include services of technician to supervise adjustments, final connections, and system start-up.

4 **END OF SECTION**

SECTION 27 05 00
BASIC COMMUNICATIONS SYSTEMS REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Basic Communications Systems Requirements specifically applicable to Division 27 sections, in addition to Division 1 - General Requirements.

1.2 SCOPE OF WORK

A. This Specification and the accompanying drawings govern the work involved in furnishing, installing, testing and placing into satisfactory operation the Communications Systems as shown on the drawings and specified herein.

B. Each Contractor shall provide all new materials as indicated in the schedules on the drawings, and/or in these specifications, and all items required to make their portion of the Communications Systems a finished and working system.

C. Description of Systems include but are not limited to the following:

1. Complete Structured Cabling System including, but not limited to:

    a. Voice and data horizontal cabling and terminations.
    b. Information outlets (IO's) including faceplates, jacks and labeling.
    c. Equipment racks, cabinets, cable management and equipment.
    d. Telecommunication Room equipment including patch panels, and termination blocks.
    e. Cabling pathways.
    f. Grounding and Bonding
    g. Testing

2. Low Voltage Communications Wiring (less than +120VAC) as specified and required for proper system control and communications.

3. All associated electrical backboxes, conduit, miscellaneous cabling, and power supplies required for proper system installation and operation as defined in the "Suggested Matrix of Scope Responsibility".

1.3 OWNER FURNISHED PRODUCTS

A. Network electronics (software and hardware devices), wireless access points and cross connects.

1.4 DIVISION OF WORK BETWEEN ELECTRICAL AND COMMUNICATIONS CONTRACTORS

A. Division of work is the responsibility of the Prime Contractor. Any scope of work described in the contract document shall be sufficient for including said requirement in the project. The Prime Contractor shall be solely responsible for determining the appropriate subcontractor for the described scope. In no case, shall the project be assessed an additional cost for scope that is described in the contract documents. The following division of responsibility is a guideline based on typical industry practice.

B. Definitions:

1. "Electrical Contractor" as referred to herein refer to the Contractors listed in Division 26 of this Specification.

2. "Electrical Contractor" shall also refer to the Contractor listed in Division 27 of this specification when the "Suggested Matrix of Scope Responsibility" indicates the work shall be provided by the EC. Refer to the Contract Documents for the "Suggested Matrix of Scope Responsibility".

3. "Communications Contractor" as referred to herein refer to the Contractors listed in Division 27 of this Specification.

4. Low Voltage Communications Wiring: The wiring (less than 120VAC) associated with the Communications Systems, used for analog and/or digital signals between equipment.

5. Telecommunications Rough-in: Relates specifically to the backboxes, necessary plaster rings and other miscellaneous hardware required for the installation and mounting of the telecommunications information outlet. Rough-in shall include conduit from the information outlet backbox to above the lay-in ceiling. Where surface mounted backboxes are required, conduit shall be routed to above the lay-in ceiling the bottom of the exposed structural joists the nearest cable tray.

C. General:

1. The purpose of these Specifications is to outline typical Electrical and Communications Contractor's work responsibilities as related to Communications Systems including Telecommunications rough-in, conduit, cable tray, power wiring and Low Voltage Communications Wiring. The prime contractor is responsible for all divisions of work.

2. The exact wiring requirements for much of the equipment cannot be determined until the systems have been purchased and submittals are approved. Therefore, only known wiring, conduits, raceways, and electrical power as related to such items, is shown on the Communications Drawings. Other wiring, conduits, raceways, junction boxes, and electrical power not shown on the Communications Drawings but required for the successful operation of the systems shall be the responsibility of the Communications Contractor and included in the Contractor's bid.

3. Where the Electrical Contractor is required to install conduit, conduit sleeves and/or power connections in support of Communications systems, the final installation shall not begin until a coordination meeting between the Electrical Contractor and the Communications Contractor has convened to determine the exact location and requirements of the installation.

4. Where the Electrical Contractor is required to install cable tray that will contain Low Voltage Communications Wiring, the installation shall not begin until the Communications Contractor has completed a coordination review of the cable tray shop drawing.

5. This Contractor shall establish Electrical and Communications utility elevations prior to fabrication and installation. The Communications Contractor shall cooperate with the Electrical Contractor and the determined elevations in accordance with the guidelines below. This Contractor shall coordinate utility elevations with other trades. When a conflict arises, priority shall be as follows:

    a. Lighting Fixtures
    b. Gravity Flow Piping, including Steam and Condensate
    c. Sheet Metal
    d. Electrical Busduct
    e. Cable Trays, including 12" access space
    f. Sprinkler Piping and other Piping
    g. Conduit and Wireway
    h. Open Cabling

D. Electrical Contractor's Responsibility:

1. Assumes all responsibility for all required conduit and power connections when shown on the "Suggested Matrix of Scope Responsibility" to be provided by the Electrical Contractor.

2. Assumes all responsibility for providing and installing cable tray.

3. Responsible for Communications Systems grounding and bonding.

4. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

E. Communications Contractor's Responsibility:

1. Assumes all responsibility for the Low Voltage Communications Wiring of all systems, including cable support where open cable is specified.

2. Assumes all responsibility for all required backboxes, conduit and power connections not specifically shown as being provided by the Electrical Contractor on the "Suggested Matrix of Scope Responsibility."

3. Assumes all responsibility for providing and installing all ladder rack and other cable management hardware (as defined in here-in).

4. Responsible for providing the Electrical Contractor with the required grounding lugs or other hardware for each piece of Communications equipment which is required to be bonded to the Communications ground system.

5. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

1.5 COORDINATION DRAWINGS

A. Definitions:

1. Coordination Drawings: A compilation of the pertinent layout and system drawings that show the sizes and locations, including elevations, of system components and required access areas to ensure that no two objects will occupy the same space.

a. Mechanical trades shall include, but are not limited to, mechanical equipment, ductwork, fire protection systems, plumbing piping, medical gas systems, hydronic piping, steam and steam condensate piping, and any item that may impact coordination with other disciplines.

b. Electrical trades shall include, but are not limited to, electrical equipment, conduit 1.5" and larger, conduit racks, cable trays, pull boxes, transformers, raceway, busway, lighting, ceiling-mounted devices, and any item that may impact coordination with other disciplines.

c. Technology trades shall include, but are not limited to, technology equipment, racks, conduit 1.5" and larger, conduit racks, cable trays, ladder rack, pull boxes, raceway, ceiling-mounted devices, and any item that may impact coordination with other disciplines.

d. Maintenance clearances and code-required dedicated space shall be included.

e. The coordination drawings shall include all underground, underfloor, in-floor, in chase, and vertical trade items.

2. The contractors shall use the coordination process to identify the proper sequence of installation of all utilities above ceilings and in other congested areas, to ensure an orderly and coordinated end result, and to provide adequate access for service and maintenance.

B. Participation:

1. The contractors and subcontractors responsible for work defined above shall participate in the coordination drawing process.

2. One contractor shall be designated as the Coordinating Contractor for purposes of preparing a complete set of composite electronic CAD coordination drawings that include all applicable trades, and for coordinating the activities related to this process. The Coordinating Contractor for this project shall be the Mechanical Contractor.

   a. The Coordinating Contractor shall utilize personnel familiar with requirements of this project and skilled as draftspersons/CAD operators, competent to prepare the required coordination drawings.

3. Electronic CAD drawings shall be submitted to the Coordinating Contractor for addition of work by other trades. IMEG Corporation will provide electronic file copies of ventilation drawings for contractor's use if the contractor signs and returns an "Electronic File Transfer" waiver provided by IMEG Corporation. IMEG Corporation will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings.

C. Drawing Requirements:

1. The file format and file naming convention shall be coordinated with and agreed to by all contractors participating in the coordination process and the Owner.

   a. Scale of drawings:

      1) General plans: 1/4 Inch = 1 '-0" (minimum).

      2) Mechanical, electrical, communication rooms, and including the surrounding areas within 10 feet: 1/2 Inch = 1'-0" (minimum).

      3) Shafts and risers: 1/2 Inch = 1'-0" (minimum).

      4) Sections of shafts and mechanical and electrical equipment rooms: 1/4 Inch = 1 '-0" (minimum).

      5) Sections of congested areas: 1/2 Inch = 1'-0" (minimum).

2. Ductwork layout drawings shall be the baseline system for other components. Ductwork layout drawings shall be modified to accommodate other components as the coordination process progresses.

3. There may be more drawings required for risers, top and bottom levels of mechanical rooms, and shafts.

4. The minimum quantity of drawings will be established at the first coordination meeting and sent to the A/E for review. Additional drawings may be required if other areas of congestion are discovered during the coordination process.

D. General:

1. Coordination drawing files shall be made available to the A/E and Owner's Representative. The A/E will only review identified conflicts and give an opinion, but will not perform as a coordinator.

2. A plotted set of coordination drawings shall be available at the project site.

3. Coordination drawings are not shop drawings and shall not be submitted as such.

4. The contract drawings are schematic in nature and do not show every fitting and appurtenance for each utility. Each contractor is expected to have included in his/her bid sufficient fittings, material, and labor to allow for adjustments in routing of utilities made necessary by the coordination process and to provide a complete and functional system.

5. The contractors will not be allowed additional costs or time extensions due to participation in the coordination process.

6. The contractors will not be allowed additional costs or time extensions for additional fittings, reroutings or changes of duct size, that are essentially equivalent sizes to those shown on the drawings and determined necessary through the coordination process.

7. The A/E reserves the right to determine space priority of equipment in the event of spatial conflicts or interference between equipment, piping, conduit, ducts, and equipment provided by the trades.

8. Changes to the contract documents that are necessary for systems installation and coordination shall be brought to the attention of the A/E.

9. Access panels shall preferably occur only in gypsum board walls or plaster ceilings where indicated on the drawings.

   a. Access to mechanical, electrical, technology, and other items located above the ceiling shall be through accessible lay-in ceiling tile areas.

   b. Potential layout changes shall be made to avoid additional access panels.

   c. Additional access panels shall not be allowed without written approval from the A/E at the coordination drawing stage.

   d. Providing additional access panels shall be considered after other alternatives are reviewed and discarded by the A/E and the Owner's Representative.

   e. When additional access panels are required, they shall be provided without additional cost to the Owner.

10. Complete the coordination drawing process and obtain sign off of the drawings by all contractors prior to installing any of the components.

11. Conflicts that result after the coordination drawings are signed off shall be the responsibility of the contractor or subcontractor who did not properly identify their work requirements, or installed their work without proper coordination.

12. Updated coordination drawings that reflect as-built conditions may be used as record documents.

1.6 QUALITY ASSURANCE

A. Telecommunications Structured Cabling System Standards:

1. All work and equipment shall conform to the most current ratified version of the following published standards unless otherwise indicated that draft standards are to be followed:

   a. TIA/EIA 569-A – Commercial Building Standard for Telecommunications Pathways and Spaces.

b. TIA/EIA 606 – Administration Standards for the Telecommunications Infrastructure of Commercial Buildings.

c. TIA/EIA 607 – Commercial Building Grounding and Bonding Requirements for Telecommunications.

d. ANSI/NECA 568 – Standard for Installing Commercial Building Telecommunications Cabling.

e. TIA/EIA 568-B – Commercial Building Telecommunications Cabling Standard

1) B.1 – Part 1: General Requirements

2) B.1-1 – Addendum 1: Minimum 4-Pair UTP and 4-Pair ScTP Patch Cable Bend Radius.

3) B.2 – Part 2: Balanced Twisted Pair Cabling Components.

4) B.2-1-2002– Addendum 1: Transmission Performance Specifications for 4-Pair 100 Ohm Category 6 Cabling.

f. UL 444 – Standard for Safety for Communications Cable.

g. NFPA 70 (NEC) – National Electrical Code.

h. NFPA 1221 – Standard for Installation, Maintenance and Use of Emergency Communications Systems

B. Refer to individual sections for additional Quality Assurance requirements.

C. Qualifications:

1. Only products of reputable manufacturers as determined by the Engineer will be acceptable.

2. The installing Contractor shall be certified by the manufacturer of the structured cabling system. Certification of Contractor shall have been in place for a minimum of one (1) year prior to bidding this project. Documentation of certification is required at the time of bid. Shop drawings will not be approved until proof of certification is submitted. Refer to the end of this specification section for certification documentation requirements.

3. Each Contractor and their subcontractors shall employ only workers who are skilled in their respective trades and fully trained. All workers involved in the termination of cabling shall be individually certified by the manufacturer.

4. The Contractor shall be experienced in all aspects of this work and shall be required to demonstrate direct experience on recent systems of similar type and size.

5. The Contractor shall own and maintain tools and equipment necessary for successful installation and testing of optical and copper structured cabling systems and have personnel adequately trained in the use of such tools and equipment.

6. The Contractor shall obtain the services of a RCDD (Registered Communications Distribution Designer) for the project. The RCDD shall perform the following tasks on the project:

a. Review contractor's submittals and stamp the submittals with a current RCDD stamp stating the submittals compliance with the contract documents.

7.

8. The Contractor shall have certified BICSI installation technicians on staff to perform the following tasks on the project:

   a. Act as the field superintendent or job foreman with the responsibility of monitoring the daily work of each technician.

   b. Oversee all testing and termination of cabling.

9. A resume of qualification shall be submitted with the Contractor's bid indicating the following:

   a. Documentation of certification of This Contractor by the proposed structured cabling system manufacturer as required at the end of this specification section.

   b. A list of recently completed projects of similar type and size with contact names and telephone numbers for each.

   c. A list of test equipment proposed for use in verifying the installed integrity of copper and fiber optic systems on the project.

   d. A technical resume of experience for the Contractor's project manager and on-site installation supervisor assigned to this project.

   e. Resume and certification of the BICSI installation technician for the project.

D. Compliance with Codes, Laws, Ordinances:

1. This Contractor shall conform to all requirements of the City of Madison, Wisconsin Codes, Laws, Ordinances and other regulations having jurisdiction over this installation.

2. In the event, there are no local codes having jurisdiction over this job, the current issue of the National Electrical Code shall be followed.

3. If there is a discrepancy between the codes and regulations having jurisdiction over this installation, and these specifications, the codes and regulations shall determine the method or equipment used.

4. If the Contractor notes, at the time of bidding, any parts of the drawings and specifications which are not in accordance with the applicable codes or regulations, he shall inform the Architect/Engineer in writing, requesting a clarification. If there is insufficient time to follow this procedure, he shall submit with the proposal, a separate price required to make the system shown on the drawings comply with the codes and regulations.

5. All changes to the system made after the letting of the contract, in order to comply with the applicable codes or the requirements of the Inspector, shall be made by the Contractor without cost to the Owner.

E. Permits, Fees, Taxes, Inspections:

1. Procure all applicable permits and licenses.

2. Abide by all applicable laws, regulations, ordinances, and other rules of the State or Political Subdivision wherein the work is done, or as required by any duly constituted public authority.

3. Pay all applicable charges for such permits or licenses that may be required.

4. Pay all applicable fees and taxes imposed by the State, Municipal and/or other regulatory bodies.

5. Pay all charges arising out of required inspections due to codes, permits, licenses or as otherwise may be required by an authorized body.

6. Pay all charges arising out of required contract document reviews associated with the project and as initiated by the Owner or authorized independent agency/consultant.

7. Pay any charges by the service provider related to the service or change in service to the project.

8. All equipment and materials shall be as approved or listed by the following (unless approval or listing is not applicable to an item by all acceptable manufacturers):

   a. Factory Mutual
   b. Underwriters' Laboratories, Inc.

F. Examination of Drawings:

1. The drawings for the Communications Systems work are diagrammatic, intended to convey the scope of the work and to indicate the general arrangements and locations of equipment etc., and the approximate sizes of equipment.

2. Contractor shall determine the exact locations of equipment and the exact routing of cabling so as to best fit the layout of the job. Scaling of the drawings will not be sufficient or accurate for determining this layout. Where a specific route is required, such route will be indicated on the drawings.

3. Where job conditions require reasonable changes in indicated arrangements and locations, such changes shall be made by the Contractor at no additional cost to the Owner.

4. If an item is either shown on the drawings, called for in the specifications or required for proper operation of the system, it shall be considered sufficient for including same in this contract.

5. The determination of quantities of material and equipment required shall be made by the Contractor from the drawings. Schedules on the drawings and in the specifications, are completed as an aid to the Contractor but where discrepancies arise, the greater number shall govern.

6. Where words "provide", "install", or "furnish" are used on the drawings or in the specifications, it shall be taken to mean, to furnish, install and terminate completely ready for operation, the items mentioned.

G. Electronic Media/Files:

1. Construction drawings for this project have been prepared utilizing Revit MEP.

2. Contractors and Subcontractors may request electronic media files of the contract drawings and/or copies of the specifications. Specifications will be provided in PDF format.

3. Upon request for electronic media, the Contractor shall complete and return a signed “Electronic File Transmittal” form provided by IMEG Corporation.

4. If the information requested includes floor plans prepared by others, the Contractor will be responsible for obtaining approval from the appropriate Design Professional for use of that part of the document.

5. The electronic contract documents can be used for preparation of shop drawings and as-built drawings only. The information may not be used in whole or in part for any other project.

6. The drawings prepared by IMEG Corporation for bidding purposes may not be used directly for ductwork layout drawings or coordination drawings.

7. The use of these CAD documents by the Contractor does not relieve them from their responsibility for coordination of work with other trades and verification of space available for the installation.

8. The information is provided to expedite the project and assist the Contractor with no guarantee by IMEG Corporation as to the accuracy or correctness of the information provided. IMEG Corporation accepts no responsibility or liability for the Contractor's use of these documents.

H. Field Measurements:

1. Before ordering any materials, this Contractor shall verify all pertinent dimensions at the job site and be responsible for their accuracy.

2. Field conditions that will result in telecommunications drops that exceed the length limitations identified in the contract documents shall be brought to the attention of the Engineer prior to installation. The cost of reworking cabling that is too long, that was not brought to the written attention of the Engineer will be borne entirely by the Contractor.

3. This Contractor shall provide the Engineer with written documentation of any cabling drops that will not be able to use the cable tray (where cable tray is available) due to the resulting cabling lengths. This documentation shall be submitted prior to installation and installation shall not commence until approved by the Engineer.

1.7 SUBMITTALS

A. Submittals shall be required for the following items, and for additional items where required elsewhere in the specifications or on the drawings.

1. Submittals list:

Referenced Specification Section	Submittal Item
27 05 26	Communications Bonding
27 05 28	Interior Communications Pathways
27 05 43	Exterior Communications Pathways
27 05 53	Identification and Administration
27 11 00	Communication Equipment Rooms
27 15 00	Horizontal Cabling Requirements
27 17 10	Testing

B. In addition to the provisions of Division 1, the following is required:

1. Submittals shall include all layout drawings; manufacturers' standard drawings; schedules; descriptive literature, catalogs and brochures; performance and test data; wiring diagrams; and all other drawings and descriptive data of materials of construction as may be required to show that the materials, equipment or systems and the location thereof conform to the requirements of the contract documents.

2. The Contractor shall submit an electronic copy of each shop drawing for review by the Architect/Engineer BEFORE releasing any equipment for manufacture or shipment.

3. Shop drawings which are larger than 11" x 17" or are plan size layout drawings such as wiring diagrams and cable tray drawings, shall be submitted on reproducible media. Submit one reproducible and one print of each drawing or plan. All Contractor approval stamps shall be made on the reproducible. The Architect/Engineer will return the reproducible copy of the shop drawings, complete with comments. This Contractor shall copy and distribute these reviewed shop drawings as required. All costs for copying and distribution of reproducible shop drawings shall be included by This Contractor in their bid.

4. The Contractor shall thoroughly review and approve all shop drawings before submitting them to the Architect/Engineer. CONTRACTOR'S APPROVAL STAMP IS REQUIRED ON ALL SUBMITTALS. APPROVAL WILL INDICATE THE CONTRACTOR'S REVIEW of all material and a COMPLETE UNDERSTANDING OF EXACTLY WHAT IS TO BE FURNISHED. Contractor shall clearly mark all deviations from the contract documents on all submittals. IF DEVIATIONS ARE NOT MARKED BY THE CONTRACTOR, THEN THE ITEM SHALL BE REQUIRED TO MEET ALL DRAWING AND SPECIFICATION REQUIREMENTS.

5. The Contractor shall provide RCDD stamp on the submittal.

6. The Contractor shall clearly mark each item with the same nomenclature applied on the drawings or in the specifications.

7. The Contractor shall clearly indicate the size, finish, material, etc.

8. All submittals shall be assembled in sets by system.

9. Each set shall be bound in a manufacturer's folder or inside of a manila file folder.

10. Each set shall contain an index of the items enclosed with a general topic description on the cover.

11. Where more than one model is shown on a manufacturer's sheet, the Contractor shall clearly indicate exactly which item and which data is relevant to the work.

12. Failure to comply with the above shall be reason to resubmit all shop drawing submittals.

13. The Engineer's responsibility shall be to review one set of shop drawing submittals for each product. If the first submittal is incomplete or does not comply with the drawings and/or specifications, the Contractor shall be responsible to bear the cost for the Engineer to recheck and handle the additional shop drawing submittals.

14. Provide documentation of all warranties required by the contract documents.

15. Submit copy of the Contractor certification form contained at the end of specification section.

C. Provide Schedule of Values for Technology Work:

1. Application forms: Use AIA Document Continuation Sheets G703 (or similar) as the form for application.

2. Provide line items on the Schedule of Values including:

   a. Structured Cabling
   b. Audio/Video Systems

3. Change orders shall have schedule of values broken out as listed above submitted with each change order.

4. Coordinate with the Project Engineer the items included in the Schedule of Values. The intent is to not create schedules in addition to those the Technology Contractor normally submits to the General Contractor for payment.

1.8 EQUIPMENT SUPPLIERS' INSPECTION

A. The following equipment shall not be placed in operation until a representative of the manufacturer has inspected the installation and certified that the equipment is properly installed and that the equipment is ready for operation:

1. Firestopping, including mechanical firestop systems.

1.9 PRODUCT DELIVERY, STORAGE, HANDLING & MAINTENANCE

A. Exercise care in transporting and handling to prevent damage to fixtures, equipment and materials.
B. Store materials on the site so as to prevent damage.
C. Keep fixtures, equipment and materials clean, dry and free from deleterious conditions.

1.10 WARRANTY

A. In addition to the provisions of Division 1, the following is required:

B. At a minimum, provide a one (1) year warranty for all equipment, materials, and workmanship. Individual specifications sections within Division 27 may require additional warranty requirements for specific equipment or systems.

C. Provide a structured cabling System Assurance Warranty as described herein.

D. The warranty period for the entire installation described in this Division of the specifications shall commence on the date of substantial completion unless a whole or partial system or any separate piece of equipment or component is put into use for the benefit of any party other than the installing contractor with prior written authorization. In this instance, the warranty period shall commence on the date when such whole system, partial system or separate piece of equipment or component is placed in operation and accepted in writing by the Owner or their representative.

E. Warranty requirements shall extend to correction, without cost to the final user, of all work and/or equipment found to be defective or nonconforming to the contract documents. The Contractor shall bear the cost of correcting all damage resulting from such defects or nonconformance with contract documents exclusive of repairs required as a result of improper maintenance or operation, or of normal wear as determined by the Architect/Engineer.

1.11 INSURANCE

A. This Contractor shall maintain insurance coverage as set forth in Division 1 of these specifications.

1.12 MATERIAL

A. Where several manufacturers' names are given, the first named manufacturer constitutes the basis for job design and establishes the equipment quality required to be used in this contract.

PRODUCTS

1.13 REFER TO INDIVIDUAL SECTIONS

PART 2 - EXECUTION

2.1 JOBSITE SAFETY

A. Neither the professional activities of the Engineer, nor the presence of the Engineer or his or her employees and sub-consultants at a construction site, shall relieve the Contractor and any other entity of their obligations, duties and responsibilities including, but not limited to, construction means, methods, sequence, techniques or procedures necessary for performing, superintending or coordinating all portions of the work of construction in accordance with the contract documents and any health or safety precautions required by any regulatory agencies. The Engineer and his or her personnel have no authority to exercise any control over any construction contractor or other entity or their employees in connection with their work or any health or safety precautions. The Contractor is solely responsible for jobsite safety. The Engineer and the Engineer's consultants shall be indemnified and shall be made additional insureds under the Contractor's general liability insurance policy.

2.2 GENERAL INSTALLATION REQUIREMENTS

A. Installation of all conduit and cabling shall comply with Sections 26 05 33 and 26 05 13. Additional conduit requirements described within this Division shall be supplemental to the requirement described in Section 26 05 33. Should conflicts exist between the two Divisions the more stringent (more expensive material and labor) condition shall prevail until bidding addendum or construction clarification or RFI can be submitted and responded to. In no case shall the Contractor carry the least stringent condition in the pricing.

B. It is the Contractor's responsibility to survey the site and include all necessary costs to perform the installation as specified.

C. All cables and devices installed in damp or wet locations, including any underground or underslab location, shall be listed as suitable for use in such environments. Follow manufacturer's recommended installation practices for installing cables and devices in damp or wet locations. Any cable or device that fails as a result of being installed in a damp or wet location shall be replaced at the Contractor's expense.

2.3 FIELD QUALITY CONTROL

A. General:

1. Refer to specific Division 27 sections for further requirements.

2. The Contractor shall conduct all tests required and applicable to the work both during and after construction of the work.

3. The necessary instruments and materials required to conduct or make the tests shall be supplied by the Contractor who shall also supply competent personnel for making the tests who has been schooled in the proper testing techniques.

4. In the event the results obtained in the tests are not satisfactory, This Contractor shall make such adjustments, replacements and changes as are necessary and shall then repeat the test or tests which disclose faulty or defective work or equipment, and shall make such additional tests as the Architect/Engineer or code enforcing agency deems necessary.

5. All telecommunications tests that fail, including those due to excessive cabling lengths, shall be remedied by the Contractor without cost to the project.

B. Protection of cable from foreign materials:

1. It is the Contractor's responsibility to provide adequate physical protection to prevent foreign material application or contact with any cable type. Foreign material is defined as any material that would negatively impact the validity of the manufacturer's performance warranty. This includes, but is not limited, to overspray of paint (accidental or otherwise), drywall compound, or any other surface chemical, liquid or compound that could come in contact with the cable, cable jacket or cable termination components.

2. Overspray of paint on any cable, cable jacket or cable termination component will not be accepted. It shall be the Contractor's responsibility to replace any component containing overspray, in its entirety, at no additional cost to the project. Cleaning of the cables with harsh chemicals is not allowed. This requirement is regardless of the PASS/FAIL test results of the cable containing overspray. Should the manufacturer and warrantor of the structured cabling system desire to physically inspect the installed condition and certify the validity of the structured cabling system (via a signed and dated statement by an authorized representative of the structured cabling manufacturer), the Owner may, at their sole discretion, agree to accept said warranty in lieu of having the affected cables replaced. In the case of plenum cabling, in addition to the statement from the manufacturer, the Contractor shall also present to the Owner a letter from the local Authority Having Jurisdiction stating that they consider the plenum rating of the cable to be intact and acceptable.

2.4 PROJECT CLOSEOUT

A. Refer to the Division 1 Section: PROJECT CLOSEOUT for requirements. The following paragraphs supplement the requirements of Division 1.

B. Final Jobsite Observation:

1. The Engineer will not perform a final jobsite observation until the project is ready. This is not dictated by schedule, but rather by completeness of the project.

2. Refer to the end of this specification section for a "STATEMENT INDICATING READINESS FOR FINAL JOBSITE OBSERVATION."

3. The Contractor shall sign this form and return it to the Engineer so that the final observation can commence.

C. Before final payment will be authorized, this Contractor must have completed the following:

1. Submitted operation and maintenance manuals to the Architect/Engineer for review.

2. Submitted bound copies of approved shop drawings.

3. Record documents including edited drawings and specifications accurately reflecting field conditions, **inclusive** of all project revisions, change orders, and modifications.

4. Submitted a report stating the instructions given to the Owner's representative complete with the number of hours spent in the instruction. The report shall bear the signature of an authorized agent of This Contractor and shall be signed by the Owner's representative as having received the instructions.

5. Submitted testing reports for all systems requiring final testing as described herein.

6. Submitted start-up reports on all equipment requiring a factory installation inspection and/or start.

7. Provide spare parts, maintenance, and extra materials in quantities specified in individual specification sections. Deliver to project site; submit receipt to Architect/Engineer prior to final payment being approved.

8. Provide System Assurance Warranty certificate for the telecommunications system.

2.5 OPERATION AND MAINTENANCE INSTRUCTIONS

A. In addition to the provisions of Division 1, the following is required:

B. Submit three (3) properly indexed and bound copies, in "D" ring style notebooks, of the Operations and Maintenance Instructions to the Architect/Engineer for approval. Make all corrections or additions required.

C. Operation and Maintenance Instructions shall include:

1. Notebooks shall be heavy duty locking three ring binders and incorporate clear vinyl sheet sleeves on the front cover and spine for slip-in labeling. "Peel and stick" labels are **not** acceptable. Sheet lifters shall be supplied at the front of each notebook. Provide "Wilson-Jones" or equal, color black. Size notebooks a minimum of 1/2" thicker than material for future inserts. Label the spine and front cover of each notebook. If more than one notebook is required, label in consecutive order. For example; 1 of 2, 2 of 2. No other forms of binding will be acceptable.

2. Prepare binder covers (front and spine) with printed title "Operation and Maintenance Instructions", title of project, and subject matter of binder when multiple binders are required.

3. Title page with project title, Architect, Engineer, Contractor, and Subcontractor with addresses, telephone numbers, and contacts.

4. Table of Contents describing all index tabs.

5. Listing of all Subcontractors and major equipment suppliers with addresses, telephone numbers, and contacts.

6. Index tabs dividing information by specification section, major equipment, or systems. All tab titles shall be clearly printed under reinforced plastic tags.

7. Copies of warranties.

8. Copies of all final approved shop drawings and submittals.

9. Copies of all factory inspection and/or equipment start-up reports.

10. Schematic wiring diagrams of the equipment which have been updated for field conditions. Field wiring shall have label numbers to match drawings.

11. Dimensional drawings of equipment.

12. Detailed parts list with list of suppliers.

13. Operating procedures for each system.

14. Maintenance schedule and procedures. Include maintenance chart that lists routine maintenance requirements and frequency over one-year time period.

15. Repair procedures for major components.

16. Replacement parts and service material requirements for each system and the frequency of service required.

17. Instruction books, cards, and manuals furnished with the equipment.

2.6 INSTRUCTING THE OWNER'S REPRESENTATIVE

A. In addition to the provisions of Division 1, the following is required:

B. Adequately instruct the Owner's designated representative or representatives in the maintenance, care, and operation of the complete systems installed under this contract.

C. Provide verbal and written instructions to the Owner's representative or representatives by FACTORY PERSONNEL in the care, maintenance, and operation of the equipment and systems.

D. The Owner has the option to make a video recording of all instructions.

E. The Architect/Engineer shall be notified of the time and place for the verbal instructions to be given to the Owner's representative so that their representative can be present if desirable.

F. Refer to the individual specification sections for minimum hours of instruction time for each system.

G. Operating Instructions:

1. The Contractor is responsible for all instructions to the Owner and/or Owner’s operating staff on the Communications Systems.

2. If the Contractor does not have Engineers and/or Technicians on staff that can adequately provide the required instructions on system operation, performance, troubleshooting, care and maintenance, they shall include in the bid an adequate amount to reimburse the Owner for the Engineer to perform these services.

2.7 SYSTEM COMMISSIONING

A. The Communications Systems included in the construction documents are to be complete and operating systems. The Architect/Engineer will make periodic job site observations during the construction period. The system start-up, testing, configuration, and satisfactory system performance is the responsibility of the Contractor. This shall include all calibration and adjustments of electrical equipment controls, equipment settings, software configuration, troubleshooting and verification of software, and final adjustments that may be required.

B. All operating conditions and control sequences shall be simulated and tested during the start-up period.

C. The Contractor, subcontractors, and equipment suppliers are expected to have skilled technicians to insure that the system performs as designed. If the Architect/Engineer is requested to visit the job site for the purpose of trouble shooting, assisting in the satisfactory start-up, obtaining satisfactory equipment operation, resolving installation and/or workmanship problems, equipment substitution issues or unsatisfactory system performance, including call backs during the warranty period through no fault of the design; the Contractor shall reimburse the Owner on a time and material basis for services rendered at the Architect/Engineer's standard hourly rates in effect at the time the services are requested. The Contractor shall be responsible for making payment to the Owner for services required that are product, installation or workmanship related. Payment is due within 30 days after services are rendered.

2.8 RECORD DOCUMENTS

A. Refer to the Division 1 Section: PROJECT CLOSEOUT for requirements. The following paragraphs supplement the requirements of Division 1.

B. Mark specifications to indicate approved substitutions, change orders, and actual equipment and materials used.

C. This Contractor shall maintain at the job site, a separate and complete set of Communications Drawings which shall be clearly and permanently marked and noted in complete detail any changes made to the location and arrangement of equipment or made to the Communications Systems and wiring as a result of building construction conditions or as a result of instructions from the Architect or Engineer. All Change Orders, RFI responses, Clarifications and other supplemental instructions shall be marked on the documents. Record documents that merely reference the existence of the above items are not acceptable. Should This Contractor fail to complete Record Documents as required by this contract, This Contractor shall reimburse Architect/Engineer for all costs to develop record documents that comply with this requirement. Reimbursement shall be made at the Architect/Engineer’s hourly rates in effect at the time of work.

D. The above record of changes shall be made available for the Architect and Engineer's examination during any regular work time.

E. Upon completion of the job, and before final payment is made, This Contractor shall give the marked-up drawings to the Architect/Engineer.

2.9 ADJUST AND CLEAN

A. Contractor shall thoroughly clean all equipment and systems prior to the Owner's final acceptance of the project.

B. Contractor shall clean all foreign paint, grease, oil, dirt, labels, stickers, and other foreign material from equipment.

C. Contractor shall remove all rubbish, debris, etc., accumulated during the Contractor's operations from the premises.

END OF SECTION

STATEMENT INDICATING READINESS FOR FINAL JOBSITE OBSERVATION

In order to assist the contractor in a timely close-out of the project, it is crucial that the final jobsite observation is not conducted prior to the project being ready. The contractor is required to review the completion status of the project at the time the observation is scheduled. This review, and the subsequent submittal of this form to the Engineer, shall indicate the contractor's agreement that the area of the project being requested for final observation is ready as defined below. The following list represents the degree of completeness required prior to requesting a final observation:

1. All cabling pathways (cable tray, ladder rack, conduit sleeves, etc) are installed and all cabling has been pulled through them.
2. All mechanical firestop products are installed and all other penetrations have been sealed.
3. All telecommunications jacks are installed in the faceplates.
4. All telecommunications cabling is pulled and at least 75% of all jacks have been terminated at the jack and at the telecom room.
5. Telecommunications testing is in progress and at least 25% of testing has been completed.
6. Telecommunications labeling has been provided on at least 25% of each type of component requiring a label.
7. All telecommunications related grounding is complete.
8. All CCTV camera rough-ins are installed.
9. All access control system rough-ins are installed.

The project will be ready for final jobsite observation prior to the requested date of the observation, according to the above list of requirements.

Prime Contractor: _____By: _____

Requested Observation Date _____Today's Date: _____

Contractor shall sign this readiness statement and transmit to Engineer at least 10 days prior to the requested date of observation.

It is understood that if the Engineer finds that the project is not complete as defined above and that the final jobsite observation cannot be completed on the requested date, the Engineer will return to the site at a later date. All additional visits to the site for the purposes of completing the final observation will be billed T&M to the Contractor at our standard hourly rates, including travel expenses or the contractor's retainage may be deducted for the same amount.

Telecommunications – Proof of Certification

There are specific Contractor qualification requirements for this project as defined in specification section 27 05 00, which may include Manufacturer Certification. This Proof of Certification document and the supporting documentation require herein, is required to be submitted at the time of bid to show compliance with the requirements of 27 05 00.

Statement of Compliance:

The named Contractor's base bid is a structured cabling solution from the connectivity manufacturer _____. Named Contractor is trained and certified, under the named manufacturer's formal certification program to provide and install all materials and work required by this project. Further, said Contractor is authorized, by the named manufacturer, to offer all product, labor and system assurance warranties required for this project by these contract documents.

The certification of this named manufacturer is valid, current and in effect as of the bid day of this project, the _____ day of _____, 20____.

The named Contractor is not employing any other sub-contractor on the telecommunications portion of this project that does not also meet this certification requirement.

Contractor Company Name: _____

Authorized Representative: (print) _____

Date: _____ Manufacturer Certification Number (if any): _____

Submit the following with the bid:

- This form.
- Proof of Manufacturer Certification indicated above.

SECTION 27 05 26
COMMUNICATIONS BONDING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Bonding Conductors
B. Bonding Connectors
C. Grounding Busbar (TMGB)
D. Rack-mount Telecommunications Grounding Busbar

1.2 RELATED WORK

A. Section 26 05 33 – Conduit
B. Section 26 05 36 – Cable Trays
C. Section 26 05 13 – Wire and Cable
D. Section 26 05 26 – Grounding and Bonding
E. Section 27 05 00 – Basic Communications Systems Requirements
F. Section 27 11 00 – Communication Equipment Rooms
G. Section 27 05 28 – Interior Communication Pathways
H. Section 27 05 53 – Identification and Administration

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for relevant standards.

B. Communications bonding system component, device, equipment, and material manufacturer(s) shall have a minimum of five (5) years documented experience in the manufacture of communications bonding products.

C. The entire installation shall comply with all applicable electrical codes, safety codes, and standards. All applicable components, devices, equipment, and material shall be listed by Underwriters' Laboratories, Inc.

1.4 REFERENCES

A. ANSI/IEEE 1100 – Recommended Practice for Power and Grounding Sensitive Electronic Equipment in Industrial and Commercial Power Systems

B. ANSI/TIA/EIA 568-C – Commercial Building Telecommunications Cabling Standard

C. ANSI/TIA/EIA 569-A – Commercial Building Standard for Telecommunications Pathways and Spaces

D. ANSI/TIA/EIA 606 – Administration Standard for the Telecommunications Infrastructure of Commercial Buildings

E. ANSI/TIA/EIA 758 – Customer Owned Outside Plant

F. ANSI-J-STD-607-A – Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications

G. IEEE 81 – IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System Part 1: Normal Measurements

H. IEEE 837 – IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding

I. NFPA 70 – National Electrical Code

J. NFPA 780 – Standard for the Installation of Lightning Protection Systems

K. UL 96 – Lightning Protection Components

L. UL 96A – Installation Requirements for Lightning Protection Systems

M. UL 467 – Grounding and Bonding Equipment

1.5 SUBMITTALS

A. Submit product data and shop drawings under provisions of Section 27 05 00 and Division 1.

B. Provide manufacturer's technical product specification sheet for each individual component type. Submitted data shall show the following:

1. Compliance with each requirement of these documents. The submittal shall acknowledge each requirement of this section, item-by-item, including construction, materials, ratings, and all other parameters identified in Part 2 - Products.

2. Manufacturer's installation instructions indicating application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

C. Provide CAD-generated, project-specific system shop drawings as follows:

1. Provide a system block diagram indicating system configuration, system components, interconnection between components, and conductor routing. The diagram shall clearly indicate all wiring and connections required in the system. When multiple devices or pieces of equipment are required in the exact same configuration (e.g., multiple identical equipment racks or sections of ladder tray), the diagram may show one device and refer to the others as "typical" of the device shown. The diagram shall list room numbers where system equipment will be located.

2. Installation details for all system components.

D. Provide system checkout test procedure to be performed at acceptance.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the site under the provisions of Section 27 05 00.

B. Store and protect products under the provisions of Section 27 05 00.

C. Contractor shall exercise care to prevent corrosion of any products prior to installation. Corroded products shall not be acceptable for use on this project.

1.7 SYSTEM DESCRIPTION

A. This section describes the requirements for the furnishing, installation, adjusting, and testing of a complete turnkey communications bonding system, including connection to the electrical ground grid.

B. Performance Statement: This specification section and the accompanying drawings are performance based, describing the minimum material quality, required features, operational requirements, and performance of the system. These documents do not convey every wire that must be installed, every equipment connection that must be made, or every feature and function that must be configured. Based on the equipment constraints described and the performance required of the system as presented in these documents, the Contractor is solely responsible for determining all components, devices, equipment, wiring, connections, and terminations required for a complete and operational system that provides the required performance.

C. This document describes the major components of the system. All additional hardware, subassemblies, supporting equipment, and other miscellaneous equipment required for complete, proper system installation and operation shall be provided by the Contractor.

D. Basic System Requirements:

1. A complete communications bonding infrastructure is required for this project. Refer to the drawings and the requirements of ANSI-J-STD-607-A and NFPA 70 for complete information.

2. The bonding system shall include, but not be limited to, the following major components:

a. Bonding Conductor for Telecommunications (BCT)
b. Telecommunications Main Grounding Busbar (TMGB)
c. Telecommunications Bonding Backbone (TBB)
d. Rack mount Telecommunications Grounding Busbar(s)
e. Bonding Conductor(s) (BC)
f. Bonding Connectors
g. Bonding system labeling and administration as defined in Section 27 05 53.

1.8 PROJECT RECORD DOCUMENTS

A. Submit documents under the provisions of Section 27 05 00.

B. Provide final system block diagram showing any deviations from approved shop drawing submittal.

C. Provide floor plans that document the following:

1. Actual locations of system components, devices, and equipment.
2. Actual conductor routing.
3. Actual system component, device, equipment, and conductor labels.

D. Provide statement that system checkout test, as outlined in the approved shop drawing submittal, is complete and test results were satisfactory.

E. Complete all operation and maintenance manuals as described below.

1.9 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Section 27 05 00.

B. Submitted data shall include:

1. Approved shop drawings.

2. Descriptions of recommended system maintenance procedures, including:

a. Inspection
b. Periodic preventive maintenance
c. Fault diagnosis
d. Repair or replacement of defective components

PART 2 - PRODUCTS

2.1 BONDING CONDUCTORS

A. Bare Copper:

1. Annealed uncoated stranded conductor.
2. Minimum size 6 AWG.

B. Insulated Copper:

1. Annealed uncoated stranded conductor.
2. Insulation:
   a. PVC insulation with nylon outer jacket.
   b. Rated ≥ 600 volts.
   c. Green.
3. Minimum size 6 AWG.

C. All bonding conductors shall be listed and recognized by a nationally recognized testing laboratory as being suitable for the intended purpose and for installation in the space in which they are installed.

D. Bonding Conductor Sizing

1. All Communications bonding system conductors shall be sized by length as follows:

Length Linear ft (m)	Size (AWG)
Less than 13 (4)	6
14 - 20 (4 - 6)	4
21 - 26 (6 - 8)	3
27 - 33 (8 - 10)	2
34 - 41 (10 - 13)	1
42 - 52 (13 - 16)	1/0
53 - 66 (16 - 20)	2/0
Greater than 66 (20)	3/0

2. The BCT shall be the same size as the TBB or larger.

2.2 BONDING CONNECTORS

A. Acceptable Types:

1. Two-hole compression lug
2. Exothermic weld
3. Irreversible compression

B. Connectors shall be provided in kit form and selected per manufacturer's written instructions.

C. Connectors shall comply with IEEE 837 and UL 467 and be listed for use for specific types, sizes, and combinations of conductors and connected items.

2.3 GROUNDING BUSBAR (TMGB)

A. Features:

1. Wall-mount configuration.
2. Listed and recognized by a nationally recognized testing laboratory as being suitable for intended purpose.
3. Hole patterns compliant with BICSI recommendations and ANSI-J-STD-607-A standards.
4. Predrilled holes.
5. Integral insulators.
6. Stainless steel offset mounting brackets.

B. Specifications:

1. Material: Electrolytic tough pitch copper bar with tin plating.

2. Minimum Dimensions: 1/4" thick x 4" high x 12" long.

   a. Increase dimensions and/or quantity furnished and installed as required to accommodate all terminations required by the project, plus 20% spare capacity.

3. Hole pattern shall include:

   a. A minimum of 15 sets of 5/16" holes, 5/8" on center, to accommodate "A" spaced 2-hole compression lugs.

   b. A minimum of three (3) sets of 7/16" holes, 1" on center, to accommodate "C" spaced 2-hole compression lugs.

2.4 RACK-MOUNT TELECOMMUNICATIONS GROUNDING BUSBAR

A. Features:

1. Listed and recognized by a nationally recognized testing laboratory as being suitable for intended purpose.

2. Predrilled holes.

3. Mounts in a standard 19" equipment rack.

B. Specifications:

1. Material: Electrolytic tough pitch copper bar with tin plating.

2. Minimum Dimensions: 3/16" thick x 3/4" high x 19" long.

   a. Increase dimensions and/or quantity furnished and installed as required to accommodate all terminations required by the project, plus 20% spare capacity.

3. Hole pattern shall include:

   a. A minimum of eight (8) 6-32 tapped lug mounting holes on 1" centers.

   b. A minimum of two (2) pairs of 5/16" diameter holes spaced 3/4" apart.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Bonding Requirements:

1. The communications bonding system shall be a complete system. Contractor shall furnish and install all necessary miscellaneous components, devices, equipment, material, and hardware, including, but not limited to, lock washers, paint-piercing washers, hex nuts, compression lugs, insulators, mounting screws, lugs, etc., to provide a complete system.

2. A licensed electrician shall perform all bonding.

3. Comply with the manufacturer's instructions and recommendations for installation of all products.

B. Main Cross Connect and Service Entrance Room Bonding Requirements:

1. Locate the TMGB in the service entrance room unless otherwise noted on the drawings.

2. The location of the TMGB shall be the shortest practical distance from the telecommunications primary lightning protection devices.

3. Bond the telecommunications primary protectors to the TMGB. Maintain a minimum 1 foot (300 mm) separation of the bonding conductor from all DC power cables, switchboard cable, and high frequency cable.

C. Telecommunications Main Ground Bar (TMGB) Requirements:

1. Install TMGB such that it is insulated from its support with a minimum 2" standoff.

2. Bond the TMGB to the electrical service ground via the BCT.

   a. A minimum of 1 foot (300 mm) separation shall be maintained between the BCT and any DC power cables, switchboard cable, or high frequency cables.

3. Where backbone or horizontal cabling contains a shield, the shield(s) shall be bonded to the TMGB.

4. TMGB shall be bonded to all electrical panels located in the same room or space as the TMGB or in an immediately adjacent space within 20 linear feet of the TMGB. TMGB shall be bonded to all electrical panels providing electrical power to communications equipment located in the same room or space as the TMGB.

5. TMGB shall be bonded to accessible metallic building structure located within the same room or space as the TMGB.

6. All metallic continuous cable pathways, including, but not limited to, cable trays, basket trays, ladder racks, raceways, conduits, conduit sleeves, and fire-rated cable pathway devices, located within the same room or space as the TMGB, shall be bonded to the TMGB.

7. All metallic communications equipment, including, but not limited to, cable pair protectors, surge suppressors, cross-connect frames, patch panels, equipment cabinets, etc., located within the same room or space as the TMGB, shall be bonded to the TMGB.

D. Rack-mount Telecommunications Ground Bar Requirements (RTGB):

1. Provide a rack-mount telecommunications ground bar in each equipment rack.

2. Install RTGB such that it is electrically bonded to the rack. Where necessary, remove paint and/or use paint-piercing washers to provide proper electrical bond between RTGB and equipment rack.

3. Bond each RTGB to the TGB via a BC.

4. If more than one (1) RTGB is provided within the same room or space, they shall all be bonded together via a BC.

5. All contractor-furnished and/or contractor-installed metallic communications equipment, including, but not limited to patch panels, fiber optic distribution enclosures, splice enclosures, active electronics, uninterruptible power supplies, etc., mounted within the same equipment rack as the RTGB, shall be bonded to the RTGB. Where necessary, remove paint and/or use paint-piercing washers to provide proper electrical bond between equipment rack and installed metallic communications equipment. Active electronics and uninterruptible power supplies shall be bonded to the RTGB via a dedicated BC for each device.

E. Metallic Interior Communication Pathway Bonding Requirements:

1. All metallic interior continuous communication cable pathways, including, but not limited to, conduit, conduit sleeves, fire-rated cable pathway devices, cable tray, basket tray, and ladder rack, shall be bonded to the communications bonding system.

F. Bonding Conductor Requirements:

1. Bonding conductors shall be green or marked with a distinctive green color.

2. Bonding conductors shall be routed parallel and perpendicular to building structure along shortest and straightest paths possible. Number of bends and changes in direction should be minimized. Install and secure conductors in a manner that protects the conductors from impact and from physical or mechanical strain or damage.

3. Bonding conductors shall not be installed in metallic conduit.

4. All conductors, including, but not limited, to the BCT, TBB, GE(s), and BC(s), shall be installed splice-free. If the Contractor believes that site conditions do not allow a splice-free installation, the Contractor may request permission from the Architect/Engineer to splice a specific communications bonding system conductor.

   a. Where documented permission to splice a conductor is granted:

      1) The number of splices shall be limited to as few as possible.

      2) Splices shall be made using exothermic welding or irreversible compression-type connections only. Splice hardware shall be listed for grounding and bonding. Solder is not an acceptable means of splicing conductors.

      3) Splices shall be made in telecommunications spaces in accessible locations to facilitate future inspection and maintenance.

      4) Splices shall be adequately supported and protected from impact and from physical or mechanical strain or damage.

5. All bonding conductors shall be labeled in accordance with the requirements of Section 27 05 53. In addition to the requirements of Section 27 05 53:

   a. Labels shall be nonmetallic.

   b. Labels shall be printer-generated.

c. Labels shall be located on conductors as close as is practical to their point of termination in a readable position.

d. Additionally, conductors shall be labeled as follows:

1) "IF THIS CONNECTOR OR CABLE IS LOOSE OR MUST BE REMOVED, PLEASE CALL THE BUILDING TELECOMMUNICATIONS MANAGER."

6. Interior water piping is not acceptable for use as a communications bonding system bonding conductor.

7. Metallic cable shields are not acceptable for use as communications bonding system bonding conductors.

G. Bonding Connection Requirements:

1. Make all connections in accessible locations to facilitate future inspection and maintenance.

2. Communications bonding system connections shall be made using exothermic welding, two-hole compression lugs, or other irreversible compression-type connections. The use of 1-hole lugs is prohibited, except for connections to a rack-mount telecommunications ground bar. Connection hardware shall be listed for grounding and bonding. Sheet metal screws shall not be used to make communications bonding system connections.

3. Thoroughly clean conductors before installing lugs and connectors.

4. Install and tighten all connectors in accordance with manufacturer's instructions, using the appropriate purpose-designed tool(s) recommended by the manufacturer for that purpose. Exercise care not to tighten connectors beyond manufacturer's recommendations.

5. Where necessary, remove paint and/or use paint-piercing washers to provide proper electrical bond at all connections.

6. All bonding connections shall be coated in anti-oxidant joint compound that is purpose-designed and purpose-manufactured for that use. Anti-oxidant joint compound shall be applied in accordance with manufacturer's recommendations and instructions.

7. All installed connectors on conductors installed in damp locations shall be sealed with dielectric grease and then covered with heat shrink tubing to protect against moisture ingress. Applied heat shrink tubing shall overlap conductor's outer jacket a minimum of four (4) inches past connector and be installed in accordance with manufacturer's recommendations and instructions.

3.2 FIELD QUALITY CONTROL

A. Field testing shall be performed under provisions of Section 27 05 00.

B. Where these specifications require a product or assembly without the use of a brand or trade name, provide a product from a reputable manufacturer that meets the requirements of the specifications.

C. Periodic observations will be performed during construction to verify compliance with the requirements of the specifications. These services do not relieve the Contractor of responsibility for compliance with the contract documents.

3.3 ADJUSTING

A. Adjust work under provisions of Section 27 05 00.

B. Contractor shall make any and all adjustments to the communications bonding system necessary to ensure that the installed system meets all requirements listed herein. Modifications necessary to comply with listed requirements or to provide specified performance shall be completed by the Contractor at no additional cost to the Owner.

3.4 TESTING

A. Test installed system under provisions of Section 27 17 10.

B. Measure and document resistance to ground at TMGB, each TGB, each RTGB, and each electrical distribution panel bonded to the TMGB or a TGB.

1. Measurements shall be made not less than two full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage, and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests by the fall-of-potential method according to IEEE 81.

2. Measured resistance to ground at TMGB, each TGB, and each RTGB must not exceed 5 ohms.

3. Under no circumstances shall any point in the communications bonding system have a lower resistance to ground than that of nearby electrical distribution system components that it is bonded to.

C. Include measurement documentation in test data submitted at completion of project under provisions of Section 27 17 10.

3.5 SYSTEM TRAINING

A. All labor and materials required for on-site system training shall be provided. Training shall be conducted at the project site using the project equipment.

1. Provide two week's advanced notice of training to the Owner and Architect/Engineer.

2. The Architect/Engineer shall be presented with the option to attend the training.

3. Provide a training outline agenda describing the subject matter and the recommended audience for each topic.

B. At a minimum, the following training shall be conducted:

1. A course detailing the system functions and operations that a technical user will encounter. Provide training on all aspects of using the system, including making new bonding connections to the TMGB, TGB, or RTGB. Provide training on all recommended inspection, maintenance, and repair procedures for the system.

C. Minimum on-site training times shall be:

1. Technical user: Four hours.

END OF SECTION

SECTION 27 05 28
INTERIOR COMMUNICATION PATHWAYS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. The work covered under this section consists of the furnishing of all necessary labor, supervision, materials, equipment, tests and services to install complete wire mesh support systems, conduits, sleeves, innerduct, etc. for an interior cabling plant as shown on the drawings.

B. Wire mesh support systems are defined to include, but are not limited to straight sections of continuous wire mesh, field formed horizontal and vertical bends, tees, drop outs, supports and accessories.

1.2 RELATED WORK

A. Section 26 05 33 - Conduit
B. Section 27 05 00 - Basic Communications Systems Requirements
C. Section 27 05 26 - Communications Bonding

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for requirements.

1.4 REFERENCES

A. ANSI/NFPA 70 - National Electrical Code

B. NEMA VE 2-2000 - Cable Tray Installation Guidelines

1.5 SUBMITTALS

A. Under the provisions of Section 27 05 00 and Division 1, prior to the start of work the Contractor shall submit:

1. Manufacturer's data covering all products proposed, including construction, materials, ratings and all other parameters identified in Part 2 - Products, below.

2. Manufacturer's installation instructions.

B. Coordination Drawings:

1. Include cable tray and conduit sleeve layout in composite electronic coordination files. Refer to Section 27 05 00 for coordination drawing requirements.

1.6 DRAWINGS

A. The drawings, which constitute a part of these specifications, indicate the general route of the wire mesh support systems, conduit, sleeves, etc. Data presented on these drawings is as accurate as preliminary surveys and planning can determine until final equipment selection is made. Accuracy is not guaranteed and field verification of all dimensions, routing, etc., is required.

PART 2 - PRODUCTS

2.1 CONDUIT

A. Refer to Section 26 05 33 for conduit requirements for this project.

2.2 WIRE MESH CABLE TRAY – OVERHEAD

A. Acceptable Manufacturers:

1. Cooper B-Line "Flextray"
2. Cablofil, Inc.
3. Wiremold "Fieldmate"

B. General: Provide wire mesh of types and sizes indicated on drawings; with connector assemblies, clamp assemblies, connector plates, splice plates and splice bars. Provide drop-out fittings where cable tray is installed over equipment racks. Two drop-out fittings shall be installed over each rack so that a controlled radius is maintained into each side of every equipment rack that cable tray passes over. Construct units with rounded edges and smooth surfaces; in compliance with applicable standards; and with the following additional construction features.

C. Wire mesh shall be made of high strength steel wires and formed into a standard 2 inch by 4-inch wire mesh pattern with intersecting wires welded together. All wire ends along wire mesh sides (flanges) shall be rounded during manufacturing for safety of cables and installers.

D. Materials and Finishes: Material and finish specifications for each wire mesh type are as follows:

1. Electro-Galvanized Zinc: Straight sections shall be made from steel meeting the minimum mechanical properties of ASTM A510 and shall be electro-plated zinc in accordance with ASTM B633 SC2. Additionally, straight sections shall be painted Flat Black.

2. Accessories:

   a. Electro-Galvanized Zinc: Support accessories and miscellaneous hardware shall be coated in accordance with ASTM B633 SC3. All threaded components shall be coated in accordance with ASTM B633 SC1.

E. Type of Overhead Wire Mesh Support System:

1. All straight section longitudinal wires shall be straight (with no bends).

2. Wire mesh supports shall be trapeze hangers or wall brackets. Center hung supports will not be allowed.

3. Trapeze hangers are to be supported by 1/4 inch or 3/8-inch diameter rods.

4. Provide manufacturer approved grounding clips as necessary for continuous grounding of tray.

2.3 CABLE HANGERS AND SUPPORTS

A. Provide a non-continuous cable support system suitable for use with open cable.

B. Cable Hooks:

1. Construction: Flat bottom design with a minimum cable bearing surface of 1-5/8". Hooks shall have 90-degree radius edges.

2. All cable hook mounting hardware shall be recessed to prevent damage to cable during installation. Installed cabling shall be secured using a cable latch retainer that shall be removable and reusable.

3. Finish: Pre-galvanized steel, ASTM A653 suitable for general duty use.

C. Cable Hangers:

1. Adjustable, non-continuous cable support slings for use with low voltage cabling.

2. Steel and woven laminate construction, rated for indoor non-corrosive use. Laminate material shall be suitable for use in plenum environments.

3. Sling length shall be adjustable to a capacity of 425 4-pair UTP cables.

4. Cabling hanger load limit shall be 100 lbs per foot.

5. Manufacturer: Erico Caddy, CableCat CAT425, Arlington Fittings Tl Series or approved equal.

PART 3 - EXECUTION

3.1 CABLE HOOK SUPPORT SYSTEM

A. In areas where cabling is not supported by cable tray, ladder rack, enclosed wireway or installed in conduit, such cabling shall be supported by an approved cable hook support system.

B. Refer to manufacturer's requirements for allowable fill capacity for selected cable hook. In no case, shall a 40% fill capacity be exceeded.

C. Cable hooks shall be securely mounted per manufacturer's instructions. In no case, shall the side-to-side travel of any cable hook exceed 6".

D. Cable hooks shall be selected based on the contractor's cable routing. Hooks shall be capable of supporting a minimum of 30 pounds with a safety factor of 3.

E. Support spans shall be based on the manufacturer's load ratings. In no case, shall a 5-foot span be exceeded.

F. The resting and supporting of cabling on structural members shall not meet the requirements for cabling support specified herein.

G. The use of tie-wraps or hook and loop type fasteners is specifically prohibited as a substitute for cable hooks specified herein.

3.2 CONDUIT AND CABLE ROUTING

A. Refer to specification section 26 05 03 for additional requirements.

B. All conduits shall be reamed and shall be installed with a nylon bushing.

C. Maintain appropriate conduit bend radius at all times. For conduits with an internal diameter of 2" or less, maintain a bend radius of at least 6 times the internal diameter. For conduits with an internal diameter greater than 2", maintain a bend radius of at least 10 times the internal diameter.

D. No conduit or sleeve containing more than two (2) cables shall exceed 40% fill ratio, regardless of length.

E. Any conduit exceeding 90' in length or containing more than two (2) 90-degree bends shall contain a pull box sized per ANSI/TIA/EIA 569 requirements.

1. A separate pull box is required for each 90' (or greater) length section.

2. A separate pull box is required after any two (2) consecutive 90-degree bends.

3. Pull box shall be located in an area that maintains accessibility of box, including the ability to remove box lid without removal or relocation of any other materials.

F. Any conduit with bends totaling 90 degrees or more shall have the fill capacity derated by 15% for each 90 degrees of cumulative bend.

G. Cables installed in any conduits that do not meet the above requirements shall be replaced at the Contractor's expense, after the conduit condition has been remedied.

3.3 WIRE MESH TRAY INSTALLATION

A. The wire mesh cable tray system shall be only for telecommunications.

B. Install wire mesh as indicated; in accordance with recognized industry practices (NEMA VE-2 2000), to ensure that the cable tray equipment complies with requirements of NEC, and applicable portions of NFPA 70B and NECA's "Standards of Installation" pertaining to general electrical installation practices.

C. Cable tray sections shall be grounded in accordance with manufacturer's recommendations using manufacturer approved hardware. Painted sections shall have paint removed at each grounding attachment point.

D. Test wire mesh support systems to ensure electrical continuity of bonding and grounding connections, and to demonstrate compliance with specified maximum grounding resistance. Refer to NFPA 70B, Chapter 18, for testing and test methods.

E. Provide sufficient space encompassing wire mesh to permit access for installing and maintaining cables.

F. Tray shall be continuous from source to termination and shall not change elevation, direction or otherwise expose cables to travel without 2" x 4" mesh support.

G. Overhead and Underfloor Tray shall be field cut using only manufacturer approved cutting device and methods. Cutting device shall be an offset blade bolt cutter; standard bolt cutters are specifically not permitted. Drop-in tray sections shall not be field cut or field modified in any way.

H. Bends in overhead and underfloor tray shall be accomplished by utilizing manufacturer's cutting guides.

I. All splices of tray shall be provided with splice washers, bars or springs as recommended by the manufacturer.

3.4 ATTACHMENT TO METAL DECKING

A. Where supports for cable trays and cable hook systems attach to metal roof decking, excluding concrete on metal decking, do not exceed 25 lbs. per hangar and a minimum spacing of 2'-0" on center. This 25-lb. load and 2'-0" spacing include adjacent electrical and mechanical items hanging from deck. If the hanger restrictions cannot be achieved, supplemental framing off steel framing will need to be added.

END OF SECTION

SECTION 27 05 43
EXTERIOR COMMUNICATION PATHWAYS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes the products and execution requirements relating to furnishing and installing exterior racks, ladders, conduits, sleeves, etc. for an exterior cabling plant.

1.2 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for relevant standards.

B. Precast Manufacturer (if applicable): Company specializing in precast concrete structures with three (3) years documented experience.

1.3 REFERENCES

A. Section 27 05 00 – Basic Communications Systems Requirements.

B. ANSI/ASTM A153 - Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

C. ANSI/ASTM A569 - Steel, Sheet and Strip, Carbon (0.15 Maximum Percent), Hot-Rolled, Commercial Quality.

D. ASTM A48 - Gray Iron Castings.

E. ASTM A123 - Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strips.

1.4 SUBMITTALS

A. Under the provisions of Section 27 05 00 and Division 1, prior to the start of work the Contractor shall submit:

1. Manufacturer’s data covering all products proposed, including construction, materials, ratings and all other parameters identified in Part 2 - Products, below.

2. Manufacturer’s installation instructions.

B. Submit shop drawings and product data under provisions of Section 27 05 00.

C. Submit manufacturer's installation instructions under provisions of Section 27 05 00.

D. Coordination Drawings:

1. Include hand holes, and conduits 1.5” and larger in coordination files. Include all in--floor and underfloor conduit in coordination files. Refer to Section 27 05 00 for coordination drawing requirements.

1.5 REGULATORY REQUIREMENTS

A. Equipment and material shall be UL (Underwriters Laboratory) listed and labeled.

PART 2 - PRODUCTS

2.1 OUTSIDE PLANT CONDUIT

A. High-Density Polyethylene (HDPE) Conduit:

1. Minimum Size: 4inches, unless noted otherwise.

2. Acceptable Manufacturers: Carlon, Chevron Phillips Chemical Company, or pre-approved equal.

3. Materials used for the manufacture of polyethylene pipe and fittings shall be extra high molecular weight, high-density polyethylene resin. The material shall be listed by PPI (Plastic Pipe Institute) and shall meet the following resin properties:

ASTM Test	Description	Values HDPE
D-1505	Density g/CM 3	< .941
D-1238	Melt Index, g/10 min Condition E	> .55 grams/10 min.
D-638	Tensile Strength at yield (psi)	3000 min.
D-1693	Environmental Stress Crack Resistance Condition B, F 20	96 hrs.
D-790	Flexural Modulus, MPa (psi)	< 80,000
D-746	Brittleness Temperature	-75°C Max

4. The pipe shall contain no recycled compound except that generated in the manufacturer's own plant from resin of the same raw material, including both the base resin and coextruded resin. The pipe shall be homogeneous throughout and free of visible cracks, holes, voids, foreign inclusions, or other defects that may affect the wall integrity.

5. Fitting and Conduit Bodies:

a. Directional Bore and Plow Type Installation: Electrofusion or universal aluminum threaded couplings. Tensile strength of coupled pipe must be greater than 2,000 lbs.

b. For All Other Types of Installation: Coupler must provide a watertight connection. The tensile strength of coupled pipe must be greater than 1,000 lbs.

c. E-loc type couplings are not acceptable in any situations.

d. Acceptable Manufacturers: ARCON, Carlon, or approved equal.

B. Fittings:

1. Sweeps: Factory manufactured RMC wrapped with 4 mil vinyl tape with a bend radius as follows:

a. Conduit internal diameter of 2" or less is 6 times the internal conduit diameter.

b. Conduit internal diameter of more than 2" is 10 times the internal conduit diameter.

2. End Caps (Plugs): Pre-manufactured and watertight. Tape is not an acceptable end cap or cover.

2.2 HAND-HOLES

A. Type:

1. Polymer concrete

B. Dimensions:

C. 17”x30”x24”Requirements:

1. Includes steel checker plate covers.

D. Acceptable Manufacturers

1. Quazite
2. Old Castle Precast Christy®
3. New Basis.

2.3 UNDERGROUND WARNING TAPE

A. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, compounded for direct-burial service.

B. Overall Thickness: 5 mils (0.125 mm).

C. Foil Core Thickness: 0.35 mil (0.00889 mm).

D. Orange colored tape 3-wide with 1-inch high black letters permanently imprinted with “CAUTION – BURIED COMMUNICATIONS LINE BELOW”. Printing on tape shall be permanent and shall not be damaged by burial operations.

E. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

F. Comply with ANSI Z535.1 through ANSI Z535.5.

PART 3 - EXECUTION

3.1 EXCAVATION, FILL, BACKFILL, COMPACTION

A. General:

1. The Contractor shall do all necessary excavating, securing, filling, backfilling, compacting, and restoration in connection with their work.

B. Excavation:

1. Excavations for trenches shall be excavated to proper dimensions to permit installation and inspection of work.

2. Where excavations are carried in error below indicated levels, thoroughly compacted sand-gravel fill, shall be placed in such excess excavations.

3. Excavations shall be protected against frost action and freezing.

4. Care shall be exercised in excavating so as to not damage surrounding structures, equipment, and buried utilities. In no case shall any major structural footing or foundation be undermined.

5. Excavation shall be performed in all ground characteristics, including rock, if encountered. Each bidder shall visit the premises and determine, by actual observations, borings, or other means, the nature of the soil conditions. The cost of all such inspections, borings, etc., shall be borne by the bidder.

6. In the case where the trench is excavated in rock, a compacted bed with a depth of 3" (minimum) of sand and gravel shall be used to support the conduit unless masonry cradles or encasements are used.

7. Where satisfactory bearing soil is not found at the indicated levels, the Architect/Engineer or their representative shall be notified immediately and no further work shall be done until further instructions are given.

8. Mechanical excavation of the trench to line and grade of the conduit, unless otherwise indicated on the drawings.

C. Dewatering:

1. The Contractor shall be responsible for the furnishing, installation, operation and removal of all dewatering pumps and lines necessary to keep the excavation free of water at all times.

D. Underground Obstructions:

1. Prior to the commencement of any excavation or digging, the Contractor shall verify all underground utilities with the regional utility locator. Provide prior notice to the locator before excavations. Contact information for most regional utility locaters can be found by calling 811. The Contractor is responsible for obtaining all utility locates for all trades on the project to determine obstructions indicated. The Contractor shall use great care in installing in the vicinity of underground obstruction.

E. Fill and Backfilling:

1. No rubbish or waste material shall be permitted in excavations for trench fill and backfill.

2. The Contractor shall provide the necessary sand for backfilling.

3. Dispose of the excess excavated earth as directed.

4. Soils for backfill shall be suitable for required stability and compaction, clean and free from perishable materials, frozen earth, debris or earth with an exceptionally high void content, and free from stones greater than 4 inches in diameter. Under no circumstances shall water be permitted to rise in unbackfilled trenches after installation has been placed.

5. All trenches shall be backfilled immediately after installation of conduit, unless other protection is directed.

6. All conduit shall be laid on a compacted bed of sand at least 3" deep. Backfill around the conduit with sand, spread in 6" layers, then compact each layer.

7. Use sand for backfill up to grade for all conduit located under building slabs or paved areas. All other conduit shall have sand backfill to 6" above the top of the conduit.

8. The backfilling above the sand shall be placed in uniform layers not exceeding 6" in depth. Each layer shall be placed, then carefully and uniformly tamped, so as to eliminate the possibility of lateral or vertical displacement.

9. Install a warning tape approximately 12 inches below finished grade over all underground duct banks. The identifying warning tape shall be as specified above.

10. Where the fill and backfilling will ultimately be under a building, floor or paving, each layer of fill shall be compacted to 95% of the maximum density as determined by AASHTO Designation T-99 or ASTM Designation D-698. Moisture content of soil at time of compaction shall not exceed plus or minus 2% of optimum moisture content as determined by AASHTO T-99 or ASTM D-698 test.

11. After backfilling of trenches, no superficial loads shall be placed on the exposed surface of the backfill until a period of 48 hours has elapsed.

3.2 RESTORATION REQUIREMENTS

A. Where soil and sod has been removed, it shall be replaced as soon as possible after backfilling is completed. All areas disturbed by work shall be restored to their original condition. The restoration shall include any necessary topsoiling, fertilizing, liming, seeding, or mulching,

END OF SECTION

SECTION 27 05 53
IDENTIFICATION AND ADMINISTRATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes the execution and administration requirements relating to the structured cabling system and its termination components and related subsystems.

B. Identification and labeling.

1.2 RELATED WORK

A. Section 27 05 00 – Basic Communications Systems Requirements

1.3 QUALITY ASSURANCE

A. Refer to section 27 05 00 for relevant standards.

1.4 SUBMITTALS

A. Under the provisions of Section 27 05 00 and Division 1, prior to the start of work the Contractor shall submit:

1. Documentation of labeling scheme.

PART 2 - PRODUCTS

2.1 LABELING

A. Adhesive labels shall meet the requirements of UL 969 (Ref D-16) for legibility, defacement and adhesion. Exposure requirements of UL 969 for indoor and outdoor (as applicable) use shall be met.

B. Insert labels shall meet the requirements of UL 969 for legibility, defacement and general exposure.

C. Labeling shall be consistent for all common elements in the project. This consistency shall include label size, color, typeface an attachment method.

D. Labels incorporating bar codes shall be either Code 39 conforming to USS-39 or Code 128 conforming to USS-128.

1. All Code 39 bar codes shall have a ratio between 2.5:1 and 3.0:1. Provide a minimum “quite zone” of 0.25” on each side of the bar code.

2. A descriptive label for reading by personnel shall be provided with any bar code. Bar codes by themselves are not acceptable.

E. Color Code: Observe the following requirements for color coding:

1. Labels on each end of a cable shall be the same color for each termination.

2. Labels for cross-connects shall be two different colors at each termination fields, representative of the color of that field.

3. Orange (Pantone 15C) shall be used for the demarcation point.

4. Green (Pantone 353C) shall be used for the termination point of network connection on the facility side of the demarc.

5. Purple (Pantone 264C) shall be used to identify the termination of cables from common equipment (PBX, computers, LANS, etc.)

6. White shall be used to identify the first-level backbone termination in the main cross-connect.

7. Gray (Pantone 422C) shall be used to identify the second-level backbone termination in the main cross-connect.

8. Blue (Pantone 291C) shall be used to identify the termination of station cabling at the telecommunications closet and/or equipment room end of the cable.

9. Brown (Pantone 465C) shall be used to identify the termination of the interbuilding backbone cable terminations.

10. Yellow (Pantone 101C) shall be used to identify the termination of auxiliary circuits, alarms, maintenance, security, etc.

11. Red (Pantone 184C) shall be used to identify the termination of key telephone systems.

12. In facilities that do not contain a main cross-connect, the color white may be used to identify second-level backbone terminations.

F. Tag all CAT 6 cables at both the Communications Equipment Room and the information outlets. Coordinate labeling scheme with the City of Madison staff during Pre-installation meeting.

2.2 DOCUMENTATION/AS-BUILTS/RECORDS

A. General:

1. Upon completion of the installation, the Contractor shall submit as-builts per the requirements of Section 27 05 00 and Division 1. Documentation shall include the items detailed in the subsections below.

2. All documentation, including hard copy and electronic forms shall become the property of the Owner.

B. Record Drawings:

1. The drawings are to include cable routes and outlet locations. Outlet locations shall be identified by their sequential number as defined elsewhere in this document. Numbering, icons and drawing conventions used shall be consistent throughout all documentation provided.

PART 3 - EXECUTION

3.1 IDENTIFICATION AND LABELING

A. Cable Labeling: Horizontal cables shall be labeled at each end.

1. Provide additional cable labeling at each pull box.

2. Cables that are routed through multiple pathway segments shall contain reference to all pathway segments in the pathway linkage field.

3. Cables that differ only by performance class shall have a suitable marking or label to indicate the higher performance class. For example, station cabling utilizing the blue color, may include blue with a white stripe to indicate the higher performance class station cabling.

B. Information Outlet Labeling: Tag all data jacks as defined herein.

C. Termination Hardware Labeling:

1. An identifier shall be provided at each termination hardware location or its label.

D. Grounding/Bonding Labeling:

1. The TMGB shall be labeled "TMGB." There shall be only one TMGB in the facility.

2. Label all TBB conductors connecting to the TMGB with a unique label, located at both ends of the TBB.

END OF SECTION

SECTION 27 11 00
COMMUNICATION EQUIPMENT ROOMS (CER)

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes the products and execution requirements related to furnishing and installing equipment for Communication Equipment Rooms. Communication Equipment Rooms include rooms for the Main Cross Connect (MC).

B. Definitions:

1. Main Cross Connect (MC): Allows single point administration of technology components for cross-connect of first level backbone cables, entrance cables and equipment cables.

C. Refer to Specification Section 27 05 28 for cable pathway and support requirements.

1.2 RELATED WORK

A. Section 27 05 00 - Basic Communications Systems Requirements
B. Section 27 05 26 - Communications Bonding
C. Section 27 05 28 - Interior Communication Pathways
D. Section 27 15 00 - Horizontal Cabling Requirements

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for applicable standards.

1.4 SUBMITTALS

A. Under the provisions of Section 27 05 00 and Division 1, prior to the start of work the Contractor shall submit:

1. Manufacturer's data covering all products including construction, materials, ratings and all other parameters identified in Part 2 - Products, below.

2. Manufacturer's installation instructions.

B. Coordination Drawings:

1. Include ladder racking, equipment racks, cable tray and conduit sleeve layout in composite electronic coordination files. Refer to Section 27 05 00 for coordination drawing requirements.

PART 2 - PRODUCTS

2.1 EQUIPMENT GROUNDING

A. Refer to specification section 27 05 26 for grounding requirements.

B. All equipment required to be grounded shall be provided with a grounding lug suitable for termination of the specified size electrode conductor.

2.2 EQUIPMENT RACKS

A. Where identified on the drawings in Communication Equipment Rooms, equipment racks shall be furnished and installed by the Contractor to house cable termination components and network electronics.

B. The equipment rack shall conform to the following requirements:

1. Standard TIA/EIA 19" Floor Rack:

a. Equipment rack shall be 84" in height, self-supporting and provide a useable mounting height of 45 rack units (RU) (1 RU = 1 ¾").

b. Channel uprights shall be spaced to accommodate industry standard 19" mounting.

c. Equipment rack shall be double side drilled and tapped to accept 12-24 screws. Uprights shall also be drilled on back to accept cable brackets, clamps, power strip(s), etc. Hole pattern on rack front shall be per TIA/EIA specifications (5/8"-5/8"-1/2"). Hole pattern on the rear shall be at 3" intervals to accept cable brackets.

d. Equipment racks shall be provided with a supply of spare screws (minimum of 24).

e. Equipment racks shall be provided with a ground bar and #6 AWG ground lug.

f. Provide all mounting hardware and accessories as required for a complete installation.

2.3 CABLE MANAGEMENT – VERTICAL AND HORIZONTAL

A. Equipment Racks:

1. Equipment racks shall be equipped with vertical and horizontal cable management hardware in the form of rings and guides. Racks shall incorporate vertical and horizontal covers, to allow an orderly, hidden, routing of copper, optical fiber, and coax jumpers from the modular patch panels and/or 110-type termination blocks to the customer provided network electronics. Vertical and horizontal cable management hardware shall be as follows:

a. Horizontal cable management hardware shall be 16 gauge cold rolled steel construction with six (6) pass-thru holes and seven (7) front-mounted 3.5" steel rod D-rings. Provide with cover designed to conceal and protect cable.

b. At a minimum, horizontal cable management hardware shall be positioned above and below (a) each grouping of two rows of jacks on modular patch panels, and (b) above and below each optical fiber patch panel and (c) each grouping of two rows of F-type connectors on coax patch panels.

c. Vertical cable management hardware shall provide for cable routing on front and rear of each rack and be 14" deep x 6" wide (minimum). Where multiple equipment racks are to be installed, this hardware shall be mounted between the uprights of adjacent equipment racks. Equipment rack uprights and the spacers shall be secured together per manufacturer's recommendations. Provide with cover designed to conceal and protect cable.

2. Each equipment rack shall be supplied with a minimum of 12 releasable (e.g., "hook and loop") cable support ties.

3. Where cable termination hardware is wall-mounted, the Contractor shall be responsible for establishing a cable pathway for jumpers routed from the equipment rack(s) to the wall. This shall be in the form of slotted ducts or troughs. Routing of jumpers via the overhead cable tray or ladder rack system is NOT acceptable. The proposed method shall be included in the submittals required by this document and shall be approved by the Architect/Engineer prior to installation.

2.4 PATCH PANELS

A. Where identified on the drawings in Communication Equipment Rooms, modular patch panels shall be furnished and installed by the Contractor for termination of copper cable.

B. Copper cabling shall be terminated in Communication Equipment Rooms on modular patch panels consisting of a modular connector system incorporating modular jacks meeting the specifications for the jacks detailed in Section 27 15 00.

C. The largest single modular patch panel configuration shall not exceed 48-Ports. Modular patch panels shall be fully populated (all ports occupied by jacks) and be provided in increments of no less than 12 jacks. High-density modular patch panels will not be accepted.

D. The modular patch panel blocks shall have the ability to seat and cut eight (8) conductors (4 pairs) at a time and shall have the ability of terminating 22- through 26-gauge plastic insulated, solid and stranded copper conductors. Modular patch panel blocks shall be designed to maintain the cables' pair twists as closely as possible to the point of mechanical termination.

E. Modular patch panels shall incorporate cable support and/or strain relief mechanisms to secure the horizontal cables at the termination block and to ensure that all manufacturers minimum bend radius specifications are adhered to.

2.5 LADDER RACK

A. Provide complete ladder rack system including metallic ladder rack, splice connectors, fastening hardware and other miscellaneous materials as required for a complete installation per manufacturer's recommendations.

B. Steel C-Channel Stringer Style Ladder Rack:

1. Rolled steel siderail stringer, 2" stringer height, 9" spaced welded rungs.

2. Steel shall meet the requirements of ASTM A1011 SS Grade 33.

3. Loading limits shall be 292 lbs/ft for 4 ft spans.

C. Ladder rack finish shall be flat black powder coat standard ASTM B633 SC3 yellow zinc dichromate.

2.6 D-RINGS

A. Rounded edge D-rings for support of cabling in vertical and horizontal configurations.

B. EIA 310D compliant, manufactured from materials meeting UL94-V0 specifications.

C. Provide ¼" screw holes for wall mounting.

D. Provide power strips on all equipment racks, unless noted otherwise. These power strips shall have the following characteristics:

1. Standard Rack Mount:

a. TIA/EIA 19" equipment rack mountable.

b. Compliant with UL-1449 Third Edition and UL-497A.

c. Provide transient suppression to 12,000-A. Protection shall be in all three modes (line-neutral, line-ground and neutral-ground).

d. Shall meet or exceed ANSI C62 Category A3 requirements.

e. Provide high-frequency noise suppression as follows:

1) >20-dB @ 50 kHz
2) >40-dB @ 150 kHz
3) >80-dB @ 1 MHz
4) >30-dB @ 6 to 1000 MHz

f. Protection Modes and UL 1449 Clamping Voltage: 475 volt L-N, L-G, and N-G.

g. Components: Nonmodular units composed of 20mm metal oxide varistors (MOV). Series inductors, SAD, or selenium cells may be used in addition to MOVs.

h. Be equipped with a 10-foot power cord.

PART 3 - EXECUTION

3.1 EQUIPMENT RACKS

A. Equipment racks shall be furnished and installed as shown on the drawings.

B. The Contractor shall bolt the rack to the floor as recommended by the manufacturer. Multiple racks shall be joined and the ground made common on each. The rack shall be stabilized by extending a brace to the wall. Alternately, overhead ladder rack by which the cabling accesses the equipment rack(s) may provide this function.

C. A space between the rack upright and the wall (approximately 4") should be provided to allow for cabling in that area. The rear of the rack should be approximately 40" from the wall to allow for access by maintenance personnel. In all cases, a minimum of 40" workspace in front of the rack is also required. Locations where these guidelines cannot be followed should be brought to the attention of the Architect/Engineer for resolution prior to installation.

D. All hardware and equipment is to be mounted between 18" and 79" above floor level. This is to afford easy access and, in the case of the lower limit, prevent damage to the components. Positioning of hardware should be reviewed and approved by the Architect/Engineer and Site Coordinator(s) prior to installation.

E. Equipment racks shall be equipped with cable management hardware as to allow an orderly and secure routing of optical fiber and/or copper cabling to the optical fiber distribution cabinets and/or modular patch panels. At minimum, one such horizontal jumper management panel shall be placed below each optical fiber distribution cabinet installed by the Contractor. Additional Jumper Management panels may be required pending installation of other cable types on the equipment rack.

F. Each rack shall be grounded to the Telecommunications Ground Bar (GND) using a #6 AWG (or larger) insulated stranded copper conductor (GREEN jacket) directly or via an adjacent grounded equipment rack. Refer to grounding requirements below.

3.2 LADDER RACK

A. Provide support for ladder rack on 4 ft centers.

B. Maintain a 1.5 safety factor on all load limits specified herein.

C. Ladder rack support shall be by 5/8” diameter threaded rod when ceiling mounted. Ladder rack requiring wall mounting shall utilize accessories supplied by the ladder rack manufacturer specifically for the purpose of wall mounting ladder rack.

3.3 D-RINGS

A. Provide D-rings for cable routing and management in all areas where open cabling is routed along the wall in an Equipment Room.

B. Locate D-rings on 24" centers vertically and horizontally.

C. Securely attach D-rings to the wall as required by the manufacturer.

3.4 GROUNDING

A. Provide a complete grounding system in accordance with the requirements of Section 27 05 26.

3.5 CONDUITS AND CABLE ROUTING

A. Refer to Section 26 05 33 for additional requirements.

B. Where conduits enter a telecommunications room, conduits shall be terminated on the wall where shown on the contract documents. Conduits entering the room from the floor shall extend 3" above the floor slab.

C. Where cabling rises vertically in a telecommunications rooms, provide vertical cable management to support the cabling from floor to ceiling level.

D. All conduits shall be reamed and shall be installed with a nylon bushing.

E. Maintain appropriate conduit bend radius at all times. For conduits with an internal diameter of 2" or less, maintain a bend radius of at least 6 times the internal diameter. For conduits with an internal diameter greater than 2", maintain a bend radius of at least 10 times the internal diameter.

END OF SECTION

SECTION 27 15 00
HORIZONTAL CABLING REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes the products and execution requirements relating to furnishing and installing horizontal communications cabling and termination components and related subsystems as part of a cabling plant. The cabling plant consists of copper cabling.

1.2 RELATED WORK

A. Section 27 05 00 - Basic Communications Systems Requirements

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for relevant standards.

B. The channel shall be required to meet the performance requirements indicated herein. The manufacturer shall warranty the performance of their system to the required performance (and not just to the Standard, should the required performance exceed the Standard).

C. Specific components of the channel shall be required, at a minimum, to meet the Standard component requirements for that particular component.

D. The installing contractor must be certified by the manufacturer of the structured cabling system.

1.4 SUBMITTALS

A. Under the provisions of Section 27 05 00 and Division 1, prior to the start of work the Contractor shall submit:

1. Manufacturer's data covering all products proposed, including construction, materials, ratings and all other parameters identified in Part 2 - Products, below.

2. Manufacturer's installation instructions.

PART 2 - PRODUCTS

2.1 HORIZONTAL CABLE

A. CAT 6 Plenum Cable:

1. The horizontal cable requirements must be met, as well as the following channel requirements.

2. CAT 6 cable shall terminate on rack-mounted modular patch panels in their respective communication equipment room as indicated on the drawings.

3. Performance tests shall be conducted at a maximum discrete test frequency of 250 MHz for the channel. All numbers given are dB per 100 meters.

4. Channel Requirements:

Insertion Loss:	250 MHz	35.8 dB
NEXT:	250 MHz	33.1 dB
PS NEXT:	250 MHz	30.2 dB

Insertion Loss:	250 MHz	35.8 dB
ACR:	250 MHz	1.5 dB
PS ACR:	250 MHz	-5.7 dB
ELFEXT	250 MHz	18.8 dB
PS ELFEXT:	250 MHz	12.3 dB
Return Loss:	250 MHz	10.0 dB

5. The jacket color for CAT 6 cable shall be blue for data applications.

6. Basis of Design:

   a. Hubbell Nextspeed CMP

2.2 FACEPLATES/JACKS

A. CAT 6 Jacks:

1. CAT 6 horizontal cable shall each be terminated at their designated work area location on RJ-45 modular jacks. These modular jack assemblies shall snap into a modular mounting frame. The combined modular jack assembly is referred to as an information outlet.

2. The same orientation and positioning of modular jacks shall be utilized throughout the installation. Prior to installation, the Contractor shall submit the proposed configuration for each information outlet type for review by the Architect/Engineer.

3. Information outlet faceplates shall incorporate recessed designation strips at the top and bottom of the frame for identifying labels. Designation strips shall be fitted with clear plastic covers.

4. Where standalone CAT 6 only modular jacks are identified, the information outlet faceplate shall be configured as to allow for the addition of one (1) additional modular jack CAT 6 to be installed to supplement each such modular jack as defined by this project. The installation of these supplemental modular jacks is NOT part of this project.

5. Any unused modular jack positions on an information outlet faceplate shall be fitted with a removable blank inserted into the opening.

6. All modular jacks will be fitted with a dust cover. Modular jacks shall incorporate a dust cover that fits over and/or into the modular jack opening. The dust cover shall be designed to remain with the modular jack assembly when the modular jack is in use. No damage to the modular jack pinning shall result from insertion or removal of these covers. Dust covers that result in deformation of the modular jack pinning, will not be accepted.

7. The information outlet faceplate shall be constructed of high impact plastic (except where noted otherwise). The information outlet faceplate color shall (1) match the faceplate color used for other utilities in the building or (2) when installed in surface raceway (if applicable), match the color of that raceway.

8. Information outlets that incorporate optical fiber shall be compliant with the above requirements plus:

   a. Be a low-profile assembly.

   b. Incorporate a mechanism for storage of cable and fiber slack needed for termination.

9. All information outlets and the associated modular jacks shall be of the same manufacturer throughout the project.

10. The CAT 6 modular jacks shall be non-keyed 8-pin modular jacks.

11. The interface between the modular jack and the horizontal cable shall be a 110-type termination block or insulation displacement type contact. Termination components shall be designed to maintain the horizontal cable's pair twists as closely as possible to the point of mechanical termination.

12. CAT 6 modular jacks shall be pinned per TIA-568A.

13. CAT 6 termination hardware shall, as a minimum, meet all of the mechanical and electrical performance requirements of the following standards:

    a. ANSI/TIA/EIA-568-A-5
    b. ANSI/TIA/EIA-568A
    c. ISO/IEC 11801
    d. IEC 603-7
    e. FCC PART 68 SUBPART F

14. The color for CAT 6 jacks shall be ivory

PART 3 - EXECUTION

3.1 CABLE INSTALLATION REQUIREMENTS

A. Horizontal Cabling:

1. The maximum horizontal cable drop length for Data UTP shall not exceed 295 feet (90 meters) in order to meet data communications performance specifications. This length is measured from the termination panel in the wiring closet to the outlet and must include any slack required for the installation and termination. The Contractor is responsible for installing horizontal cabling in a fashion so as to avoid unnecessarily long runs. Any area that cannot be reached within the above constraints should be identified and reported to the Architect/Engineer prior to installation. Changes to the contract documents shall be approved by the Architect/Engineer.

2. All cable shall be free of tension at both ends. In cases where the cable must bear some stress, Kellum grips may be used to spread the strain over a longer length of cable.

3. Manufacturer's minimum bend radius specifications shall be observed in all instances.

4. Horizontal cabling installed as open cabling shall be supported at a maximum of 5' between supports. Refer to the specifications for required cable supports.

5. Horizontal cabling installed as open cable or in cable tray shall be bundled at not less than 10' intervals with hook-and-loop tie wraps. The use of plastic cable ties is strictly prohibited.

6. The maximum conduit fill for horizontal cabling shall not exceed 40% regardless of conduit length.

7. Cable sheaths shall be protected from damage from sharp edges. Where a cable passes over a sharp edge, a bushing or grommet shall be used to protect the cable.

8. A coil of 3 feet in each cable shall be placed in the ceiling at the last support (e.g., J-hook, bridle ring, etc.) before the cables enter a fishable wall, conduit, surface raceway or box. At any location where cables are installed into movable partition walls or modular furniture via a service pole, approximately 15-feet of slack shall be left in each horizontal cable under 250 feet in length to allow for change in the office layout without re-cabling. These "service loops" shall be secured at the last cable support before the cable leaves the ceiling and shall be coiled from 100% to 200% of the cable recommended minimum bend radius.

9. To reduce or eliminate EMI, the following minimum separation distances from 480V power lines shall be adhered to:

   a. Twelve (12) inches from power lines of <5-kVa.
   b. Eighteen (18) inches from high-voltage lighting (including fluorescent).
   c. Thirty-nine (39) inches from power lines of 5-kVa or greater.
   d. Thirty-nine (39) inches from transformers and motors.

10. Information outlets shown on floor plans with the subscript "W" are intended to be used for wall mounted telephones. Back boxes for wall mounted telephones shall not be located within 12" vertically, or horizontally, from any light switches, power receptacles, nurse call devices, thermostats, or any other architectural element that would otherwise prevent the installation of a wall mounted telephone on the mating lugs.

3.2 CABLE TERMINATION REQUIREMENTS

A. Cable Terminations - Data UTP:

1. Modular patch panels shall be designed and installed in a fashion as to allow future horizontal cabling to be terminated on the panel without disruption to existing connections.

2. If the "last" patch (per rack) is greater than 50% utilized, one additional patch panel shall be provided for future use. Modular patch panels shall be sized to accommodate a minimum of 12 additional drops.

3. At information outlets and modular patch panels, the Contractor shall ensure that the twists in each cable pair are preserved to within 0.5-inch of the termination for data cables. The cable jacket shall be removed only to the extent required to make the termination.

END OF SECTION

SECTION 27 17 10
TESTING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes the testing requirements relating to the structured cabling system and its termination components and related subsystems.

1.2 RELATED WORK

A. Section 27 05 00 – Basic Communications Systems Requirements

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for relevant standards.

1.4 SUBMITTALS

A. Under the provisions of Section 27 05 00 and Division 1, prior to the start of work, the Contractor shall submit:

1. Complete information on testing procedure as described herein.

PART 2 - PRODUCTS

2.1 TESTING COPPER

A. General Requirements:

1. The Contractor is responsible to perform acceptance tests as indicated below for each sub-system (e.g., backbone, horizontal, etc.) as it is completed.

2. The Contractor is responsible for supplying all equipment and personnel necessary to conduct the acceptance tests. Prior to testing, the Contractor should provide a summary of the proposed test plan for each cable type including equipment to be used, setup, test frequencies or wavelengths, results format, etc. The method of testing shall be approved by the Architect/Engineer.

3. The Contractor shall visually inspect all cabling and termination points to ensure that they are complete and conform to the wiring pattern defined herein. The Contractor shall provide the Architect/Engineer with a written certification that this inspection has been made.

4. The Contractor shall conduct acceptance testing according to a schedule coordinated with the Owner/Architect/Engineer. Representatives of the Owner may be in attendance to witness the test procedures. The Contractor shall provide a minimum of one (1) week's advance notice to the Architect/Engineer to allow for such participation. The notification shall include a written description of the proposed conduct of the tests, including copies of blank test result sheets to be used.

5. Tests related to connected equipment of others shall only be done with the permission and presence of the Contractor involved. The Contractor shall ascertain that testing only is required to prove the wiring connections are correct.

6. The Contractor shall provide test results and describe the conduct of the tests including the date of the tests, the equipment used, and the procedures followed. At the request of the Architect/Engineer, the Contractor shall provide copies of the original test results.

7. All cabling shall be 100% fault-free unless noted otherwise. If any cable is found to be outside the specification defined herein, that cable and the associated termination(s) shall be replaced at the expense of the Contractor. The applicable tests shall then be repeated.

8. Should it be found by the Architect/Engineer that the materials or any portion thereof furnished and installed under this Contract fail to comply with the specifications and drawings with respect or regard to the quality, amount, or value of materials, appliances, or labor used in the work, it shall be rejected and replaced by the Contractor and all work disturbed by changes necessitated in consequence of said defects or imperfections shall be made good at the Contractor's expense.

1) Horizontal Cable:

a) Testing shall be from the modular jack at the information outlet in the work area to the 110-type termination block on which the cables are terminated at the Communication Equipment Room.

b) All horizontal cable shall be free of shorts within the pairs and be verified for continuity, pair validity and polarity, and conductor position on the modular jack (e.g., wire map). Any defective, split, or mis-positioned pairs must be identified and corrected.

b. CAT 6 Cable:

1) Testing shall be from the modular jack at the information outlet to the modular patch panel in the communication equipment room.

2) Horizontal cable shall be free of shorts within the pairs, and be verified for continuity, pair validity and polarity, and conductor position on the modular jack (e.g., wire map). Any defective, split, or mis-positioned pairs must be identified and corrected.

3) CAT 6 horizontal cable shall also be tested to 250 MHz as defined by TIA/EIA-568-C.2. Measurements shall be of the "Basic Link" including cabling and modular jacks at the information outlet and modular patch panel. Parameters to be tested must include:

a) Wire Map
b) Length
c) NEXT Loss (Pair-to-Pair)
d) NEXT (Power Sum)
e) ELFEXT (Pair-to-Pair)
f) ELFEXT (Power Sum)
g) Return Loss
h) Attenuation
i) Propagation Delay
j) Delay Skew

4) The maximum length of horizontal cable shall not exceed 295 feet (90m), which allows 33 feet (10 m) for technology equipment and modular patch cords.

5) To establish testing baselines, cable samples of known length and of the cable type and lot installed shall be tested. The cable may be terminated with an eight-position CAT 6 modular connector (8-pin) to facilitate testing. Nominal Velocity of Propagation (NVP) and nominal attenuation values shall be

calculated based on this test and be utilized during the testing of the installed cable plant. This requirement can be waived if NVP and nominal attenuation data is available from the cable manufacturer for the exact cable type under test.

6) CAT 6 horizontal cable testing shall be performed using a test instrument designed for testing to 250 MHz or higher. Test records shall verify, "PASS" on each cable and display the specified parameters, comparing test values with standards based "templates" integral to the unit. Test records that report a PASS*, FAIL*, or FAIL result for any of the parameters will not be accepted.

7) In the event results of the tests are not satisfactory, the Contractor shall make adjustments, replacements, and changes as necessary and shall then repeat the test or tests that disclosed faulty or defective material, equipment, or installation methods, and shall make additional tests as the Architect/Engineer deems necessary at no additional expense to the project or user agency.

2.2 DOCUMENTATION/AS-BUILTS/RECORDS

A. General:

1. Upon completion of the installation, the Contractor shall submit as-builts per the requirements of Section 27 05 00 and Division 1. Documentation shall include the items detailed in the subsections below.

2. All documentation, including hard copy and electronic forms, shall become the property of the Owner.

3. The Architect/Engineer may request that a 10% random field retest be conducted on the cable system at no additional cost to verify documented findings. Tests shall be a repeat of those defined above. If findings contradict the documentation submitted by the Contractor, additional testing can be requested to the extent determined necessary by the Architect/Engineer, including a 100% retest. This retest shall be at no additional cost to the Owner.

B. Copper Media Test Data:

1. Test results shall include a record of test frequencies, cable type, conductor pair and cable (or Outlet) I.D., measurement direction, test equipment type, model and serial number, date, reference setup, and crew member name(s).

2. Printouts generated for each cable by the wire test instrument shall be submitted as part of the documentation package. The Contractor shall furnish this information in electronic form (CD-ROM). The CD-ROM shall contain the electronic equivalent of the test results as defined by the bid specification and be of a format readable by Microsoft Word (Version 6.0 or newer). The Contractor shall provide a licensed copy of the software required to view and print the data that is provided in a proprietary format. The Contractor shall furnish one (1) copy of the Data and Display (if applicable) software.

PART 3 - EXECUTION

NOT APPLICABLE

END OF SECTION

SECTION 27 17 20
SUPPORT AND WARRANTY

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes support and warranty requirements relating to the structured cabling system and related subsystems.

1.2 RELATED WORK

A. Section 27 05 00 – Basic Technology Systems Requirements.

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for relevant standards.

PART 2 - PRODUCTS

2.1 MANUFACTURER REQUIREMENTS

A. The Basis of Design for all structured cabling components is listed on the drawings within the General Technology Equipment Schedule.

2.2 WARRANTY

A. A twenty-five (25) year Product Installation Warranty and System Assurance Warranty shall be provided for the structured cabling system as described in the contract documents.

B. The Product Installation Warranty shall cover the replacement or repair of the defective product(s) and labor for the replacement or repair of such defective product(s).

C. The system assurance warranty shall cover the failure of the wiring system to support the application it was designed to support, as well as additional applications introduced in the future by recognized standards or user forums that use the TIA/EIA 568A component and link/channel specifications for cabling.

D. Upon successful completion of the installation and subsequent inspection, the Owner shall be provided with a numbered certificate from the manufacturing company registering the installation.

PART 3 - EXECUTION

NOT APPLICABLE

END OF SECTION

SECTION 27 20 00
FIRE STATION ALERTING
"FOR REFERENCE ONLY"

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes the products and execution requirements related to furnishing and installing equipment for the Fire Station Alerting System. System shall be a US Digital Designs "Phoenix G2" system or equal. It shall be capable of interfacing to, and receiving alerts from a data network, radio network and two-tone paging system.

B. The work under this section is for Owner provided and installed Fire Station Alerting devices and Owner provided backboxes. The contractors work include installation of the backboxes given to them by the owner and contractor provided conduits and all cabling. Refer to Specification Section 27 05 28 for cable pathway and support requirements.

1.2 RELATED WORK

A. Section 27 05 00 - Basic Communications Systems Requirements
B. Section 27 05 26 - Communications Bonding
C. Section 27 05 28 - Interior Communication Pathways
D. Section 27 15 00 - Horizontal Cabling Requirements

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for applicable standards.

1.4 SUBMITTALS

A. Under the provisions of Section 27 05 00 and Division 1, prior to the start of work the Contractor shall submit:

1. Contractor licenses and qualifications are required as part of the complete Division 27 submittal package as indicated under Specification 27 00 05.

2. No submittals are required for the Owner provided USDD equipment.

3. Contractor to follow Manufacturer's installation instructions for backboxes, conduits and cabling requirements for a complete USDD Fire Station Alerting system

1.5 SUMMARY

1. The City of Madison IT department shall work with the manufacturer of the UDSS Fire Station Alerting System to provide all backboxes and all devices necessary for the complete system. The City of Madison IT department will also work with the manufacture to provide all product firmware and software necessary for a complete installation and upgrades for a period of the warranty. The contractor shall work with the City of Madison IT department to install the backboxes provided along with providing all conduits and cabling necessary for a complete system. Contractor is to work with the City of Madison IT Department for termination and testing of the cabling for each device the City of Madison IT Department installs. Contractor to follow all manufacturer recommendations and requirements for installation of all cabling.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The products specified shall be new and of the standard manufacture of a single reputable manufacture. As a reference of standard and quality, functionality and operation, it is a request of the Owner that bids be based on equipment manufactured by US Digital Designs, Tempe, Arizona.

2.2 CABLING

A. Cabling shall be in strict accordance with local codes and to the cable specifications found in the manufacturer's installation manual.

B. All peripheral network cabling shall be ANSI/TIA-568-B Category 6 UTP plenum rated cable. Cable jacket shall be yellow in color. Certification documents shall be provided for all cabling runs. Refer to Cable specification 27 15 00 for Horizontal Cabling requirements

C. Message Remote message sign data cable shall be a minimum of 6 conductor cable with 6 conductor modular plugs attached at both ends. Wiring shall be straight through wiring (DO NOT turn over conductors). Message Sign to Message Remote cabling shall be no longer than 25 feet to observe proper serial operation.

D. All speaker cabling shall be 18 gauge, 2-conductor stranded jacketed cables for speakers only and 18 gauge, 4-conductor stranded jacketed cables for Jupiter speaker lights.

E. All wiring shall be free of shorts and faults. Wiring shall be UL listed, NEC and NFPA 70, Article 25 approved. Terminate all network cabling on approved patch panels. Label each jack panel with room number of each terminating jack and the end of corresponding cable with jack panel number and jack number. Terminate all 4 pairs of Category 6 cable on manufacturer approved connectors and test and certify all connection to 100 MHz. Provide all cabling test certifications after testing.

2.3 FIRE STATION CONTROLLER EQUIPMENT

A. All equipment is furnished and installed by Owner. Each unit shall have the following equipment factory installed and interconnected: Fire Station Controller, Audio Tone Unit – ATU, 24 port Ethernet Switch, 24-port Ethernet Audio Mixer. UPS, Cabling Patch Panels, Radio mounting bracket.

2.4 MESSAGE REMOTES

A. Owner furnished and installed as shown on plans. Capable of dual message sign control, independently controlled dual 15-watt audio amplifier, lighting control, flush or surface mountable., single cable connection.

2.5 ROOM REMOTES

A. Owner furnished and installed as shown on plans. Capable of integrated message display, 15-watt audio amplifier, lighting control, flush or surface mountable., single cable connection.

2.6 SPEAKER SYSTEMS

A. Speaker system shall be 70 volts. Speakers shall be grouped into "areas" of similar sound level and unit alerting requirements.

B. City of Madison IT Department will furnish speaker(s): Manufacturer recommended: Juniper, Bogen S86T725PG8W in corridors and rooms. US Digital Design Low voltage lighted LED Jupiter speakers for lighted applications and Bogen NEAR A2 speakers for weather resistant applications.

PART 3 - EXECUTION

3.1 SUPERVISION

A. Equipment racks shall be furnished and installed as shown on the drawings. Only Factory trained installers shall install, service and maintain the specified system.

3.2 ROUGH OPENINGS

A. The Phoenix G2 Station Alerting System Station Alerting system shall be mounted in the 19-inch equipment rack in the telecommunications room.

B. The Room Remote devices require a minimum of a 5.5" High x 13.5" Wide opening. Typical mounting height if wall mounted is 48" AFF, Contractor to provide back box appropriately sized for equipment being furnished, confirm all sizes of back boxes with manufacturer before installation.

C. Provide access panels in drywall ceilings where access is restricted to devices above ceilings.

3.3 WIRING

A. All peripheral network cables terminate in a patch panel located in the Station Controller Cabinet. Each peripheral requires a single telecommunications outlet. Jack to be a Panduit CJ Mini-Com type jack or equivalent for Category 6 cable installation. Contractor to test and certify all connections to 250 MHz. Provide all cabling test certifications after testing. Contractor is to provide the patch panel, jack and cabling described in the beginning of this note.

B. All speaker cables shall be as noted under products for the basis of design.

C. All wiring shall be free of shorts and faults. Wiring shall be UL Listed, NEC and NFPA 70, Article 25 approved.

D. 8 ohm speakers shall have cabling run to nearest speaker, Message Remote or Room Remote. 70-volt speaker shall have cabling run to nearest speaker, Message Remote with 70 volt transformer, or home run to Station Controller.

E. Label both ends of all network cabling and all speaker cabling. Label patch panel for Station Controller.

3.4 OUTLET BOXES

A. Provide pull string in all empty conduits installed for these devices. All conduits to have bushings at ends for protection of cabling that will be installed. No conduit shall be smaller than 3/4".

B. Message Remote – provide a 4" metal box with mud ring as indicated on drawings. Center box above doorway or as directed by architect. Orient mud ring opening horizontally. Provide a minimum of (1) ¾" conduit between Message Remote to nearest accessible ceiling, cable tray or other location. Any units mounted in hard ceilings shall be routed from j-box to nearest accessible ceiling.

C. Ceiling Speakers mounted suspended ceiling shall have Bogen RE84 ceiling speaker enclosures as required.

D. Ceiling Speakers mounted in hard ceiling shall have Bogen TB8 ceiling speaker enclosures as required.

E. Apparatus Bay, Exterior or weather resistant speakers shall be mounted in a 4" metal box with mud ring at each location. Provide a ¾" diameter hole centered in the j-box cover with a bushing to allow speaker cable to run to speaker. Typically the apparatus bay speakers are located at +13' AFF, typically outside speakers are located at +11' AFF.

F. Room Remote, provide ¾" empty conduit from rough opening to nearest accessible ceiling. Rough opening to be located at 48" AFF typical and no more than +64" AFF.

3.5 SPEAKERS

A. Ceiling speakers shall include tile bridges per manufacturer's recommendations. Connect Speakers to Room Remotes and Message Remotes. Provide 70 volt transformers as required

B. Apparatus Bay Speakers shall be in enclosures and connect to Room Remotes or Message Remotes.

3.6 EQUIPMENT MOUNTING

A. All equipment mounting to be to drywall shall use appropriate fasteners and anchors

3.7 ELECTRICAL POWER CONNECTIONS

A. It shall be the responsibility of all trades to provide the appropriate number of dedicated 120 volt, 20-amp duplex receptacles for equipment cabinet rough openings. Provide equipment labeling "Station Alerting" on all equipment for this system.

3.8 ENVIRONMENTAL PROTECTION

A. Make certain that all equipment is accessible for service.

3.9 CONNECTIONS TO OTHER EQUIPMENT

A. Lighting Controller. Connect low voltage dry contact lighting controls to Room Remote, Message Remote and other ATU outputs – if required by Owner. These controls are provided by a different specification section.

B. Local Area Network. Connect the Fire Station Controller to the LAN located at the Fire Station. This connection shall be connected back to the Communications Gateway to allow alerting commands to be sent from the Communications Gateway to the Fire Station Controller. In addition, the connections allow remote diagnostics and configuration. The LAN is provided by the City of Madison.

C. Radio System. Connect Audio input #1 to the dispatch voice radio system (provided by others) as necessary to provide dispatch audio. This connection shall provide a 600-ohm impedance 0 dBm level signal.

D. Telephone system Intercom. Connect Audio Input #3 to an intercom output from the building telephone system (provided by others). This line shall be provided via a jack box located directed adjacent to the Station Alerting system equipment.

E. Other Audio Source. Connect Audio Input #4 to an audio source (provided by others). This line shall be provided via a jack box located directly adjacent to the Station Alarming System equipment.

END OF SECTION

SECTION 27 21 33
WIRELESS ACCESS POINTS (WAP)

PART 1 – GENERAL

1.1. SCOPE

A. The work under this section is for the installation of OWNER PROVIDED, CONTRACTOR INSTALLED Wireless Access Points (WAP).

B. The WAPs shall be installed by the contractor providing and installing the Communications Cable and Equipment. All contractor qualifications and certifications for that section shall apply to this section.

1.2. RELATED SPECIFICATIONS

A. The Contractor shall be responsible for reviewing all other specifications for requirements associated with the complete installation of WAP's. This includes but is not limited to the following:

1. 01 31 23 Project Management Web Site
2. 01 33 23 Submittals
3. 27 00 05 Communications Cabling

1.3. SUBMITTALS

A. Contractor licenses and qualifications are required as part of the complete Division 27 submittal package as indicated under Specification 27 00 05.

B. No submittals are required for the owner provided WAP.

C. Submittals are required for installation/hanger equipment, connectors, and any other required equipment/material required for a complete WAP installation.

PART 2 - PRODUCTS

2.1. WIRELESS ACCESS POINT (WAP) DEVICES

A. The City of Madison Information Technology Department (CoM-IT) will be providing the WAP devices for this project.

B. The WAP device being used will be as manufactured by the Cisco, Model 3700E and shall be used for all types of ceiling mounted installations (suspended, gyp board, open truss, etc).

PART 3 - EXECUTION

3.1. OWNER RESPONSIBILITIES

A. The CoM-IT shall be responsible for ordering, making payment (including shipping fees), and configuring all WAP devices in a timely manner to comply with the Contractors schedule.

B. The CoM-IT shall configure and test each WAP to CoM-IT specifications prior to providing them to the contractor for installation.

C. The CoM-IT shall number each WAP and provide the contractor with a location map indicating where each WAP will be installed.

C. The CoM-IT shall test all WAP's after installation to verify configuration and signaling is correct prior to accepting the final installation of the WAP system.

3.2. CONTRACTORS RESPONSIBILITIES

A. The Contractor shall be solely responsible for coordinating with CoM-IT the scheduling and receipt of all WAP devices with his/her installation schedule.

B. The Contractor shall inspect all WAP devices upon receipt for damage. CoM-IT shall be notified immediately of any damage.

C. The Contractor shall provide all mounting hardware, blocking, and other items required for a complete installation to the manufacturers installation requirements.

D. The Contractor shall install all WAP devices per plans and specifications including cable connections.

E. The Contractor shall be responsible to pick up WAP devices from City IT and delivery to the jobsite.

3.3. FINAL TESTING

A. Contractor shall provide final testing of all WAP devices after installation is complete.

B. In the event any WAP device is not operating properly the contractor shall trouble shoot the installation and work with the CoM-IT to determine if re-configuration of the device will be required.

C. The CoM-IT shall be responsible for reconfiguring WAP's as needed after installation is complete. The contractor shall be responsible for verifying connections, cabling and connectivity of the installation is correct.

3.4. WARRANTY

A. The CoM-IT will be responsible for registering any warranty information associated with the purchase and ownership of all WAP devices.

B. The Contractor shall warrant the installation of the WAP device for one (1) year per the terms of this contract.

END OF SECTION

SECTION 27 41 23
AUDIO-VIDEO ACCESSORIES
"FOR REFERENCE ONLY"

PART 1 – GENERAL

1.1. SUMMARY

A. This specification shall identify equipment and accessories required for to complete Audio-Video (A/V) installations not previously identified in other Division 27 specifications. It does include materials such as cables, boxes, connectors, conduit, supports required to complete the installation.

B. This specification shall clearly identify responsibilities of various contractors and the Owner including project coordination, installation, and testing of installed components.

1.2. RELATED SPECIFICATIONS

A. 01 31 23 Project Management Web Site
B. 01 33 23 Submittals
C. 01 78 23 Operation and Maintenance Data
D. 01 78 36 Warranties
E. 01 78 39 As-Built drawings
F. All Division 27 specifications that may apply to this installation
G. Other division specifications that may apply to this work for coordination

1.3. AREAS OF RESPONSIBILITY

A. The General Contractor shall be responsible for ensuring all of the following:
   1. Coordinate with the Contractor and the Owner or Owners Representative the scheduling, purchasing, and receiving of all Owner provided products and equipment.
   2. Coordinate all Contractor related work with the construction schedule.
   3. Coordinate all required Work with the Contractor and other trades during pre-installation meetings and resolve installation issues as needed.

B. The Contractor shall be responsible for all of the following:
   1. Direct coordination with the Owner or Owners Representatives for all equipment being provided and/or configured by the Owner.
   2. Verification of Owner installation requirements prior to installing equipment and accessories.

C. The Owner or Owners Representatives shall be responsible for all of the following:
   1. Coordinating all purchases and deliveries of the Owner provided equipment to the project site with the GC and Contractor so as not to delay the installation or project schedule.
   2. Coordinate the pre-installation configuration of any A/V equipment so as not to delay the installation or project schedule.

1.4. SUBMITTALS

A. The Contractor shall not be required to provide submittals for equipment being provided by the Owner but shall provide submittals for ancillary equipment as needed under this specification or other Division 27 specifications.

B. The Contractor shall provide submittals of the following:

1. All applicable licenses of the Contractor and the Contractor's installation team. Applicable licenses shall be current from the start of the contract through the end of the warranty period.
2. One (1) submittal for all ancillary A/V and A/V Contractor provided equipment required for a complete A/V installation as follows:
   a. Product information sheets and shop drawings indicating each type/size/model of A/V accessory required for a complete A/V installation. Information sheets shall include the following information:
      i. Performance data for the item
      ii. Plan identification number(s) where applicable
      iii. Quantity required for each model

1.5. WARRANTY

A. The Contractor shall also provide all manufacturers warranties/guarantees associated with only contractor installed components of the installation.

PART 2 - PRODUCTS

2.1. PRODUCTS FURNISHED BY OWNER

A. The following products shall be furnished by the owner under this specification.
   1. IPTV cable boxes
   2. All monitor wall mounts
   3. Power Amplifiers
   4. Wall monitors as indicated in the plans and specifications (see section 2.3 below).

2.2 WALL MONITORS

A. New wall monitors furnished by the City of Madison (Owner).
   1. Sizes shall include 60" and 90" monitors.

2.3. WALL MOUNTS (MONITOR)

A. The City of Madison (Owner) shall provide wall mount brackets for all wall monitor installations noted in the construction documents.

B. Wall mount brackets shall be appropriately sized to support the monitor sizes described in the construction documents. Mount brackets are to be by the City of Madison (Owner).

2.4 POWER AMPLIFIER

A. The City of Madison (Owner) shall provide the Power Amplifier for the Sound System.

2.5. IP CABLE BOX

A. IP Cable Boxes shall be provided by the Owner and installed by the Contractor. This section is being provided as informational only. The Contractor shall be responsible for providing/installing the input to the cable box and the output to the monitor.
   1. Amino Communications, Aminet A140, cable box
      a. Input = Ethernet 10/100 BaseT via RJ-45 shielded connector
      b. Output = HDMI 1.3A with HDCP
      c. Power = 120V
      d. Decodes up to 720p and 1080i; displays up to 1080p
      e. HD graphics up to 1280x720

B. The Owner shall designate which model is required at each location.

2.6 PRODUCTS FURNISHED BY CONTRACTOR

A. The Contractor shall furnish all cabling, backboxes and conduits required for a complete A/V installation per the plans and specifications except where indicated as furnished by Owner.

B. All products, materials and equipment furnished by the contractor shall be new and meet all applicable codes.

C. The Contractor shall provide the following equipment as noted within this specification:

2.7 SPEAKERS

A. The contractor shall provide the following speakers or those of similar quality.
   1. Bogen Model: S810T725PG8WVR. 70 or 25 volt, 4 watt, ceiling mounted. Provide speaker and all mounting hardware to make for a complete installation.
   2. Bogen WBS810T725, 70 or 25 volt, 4 watt, wall mount. Provide speaker and all mounting hardware to make for a complete installation.

PART 3 - EXECUTION

3.1. CONTRACTOR COORDINATION

A. The Contractor shall coordinate with the General Contractor (GC) and all other trade contractors as needed for the installation of the A/V Accessories. Coordination shall include a pre-installation meeting during rough-in to ensure blocking, power outlets, and data outlets are properly located.

B. The Contractor shall review all plans and specifications indicating wall and position requirements for accessory A/V equipment and install all required equipment accordingly.
   1. The Contractor shall coordinate all connection and installation requirements with other trade contractors doing Division 27 Work.

3.2. GENERAL INSTALLATION REQUIREMENTS

A. Cables/cords shall be properly plugged in. Excess cable/cord shall be neatly looped and bundled using Velcro cable ties. Zip ties, wire ties, and other rigid, semi-permanent restraints will not be allowed.
   1. Excess cables/cords shall not be visible after the installation is complete.
      a. Example: Cables/cords behind wall monitors shall be neatly bundled behind the monitor and fastened to the monitor wall mount so as not to be visible from the front of the monitor.

B. Equipment mounts shall be properly sized for the equipment being supported. Fasteners shall be of sufficient strength to support the finished installation including required equipment.
   1. Fasteners shall be firmly attached to blocking where provided.
   2. Fasteners in solid materials such as concrete, brick, etc shall use appropriate sleeves and anchors for the material, weight being supported, and fastener being used.
   3. All drop ceiling mount locations shall have tile bridge supports.

C. Final testing of A/V components shall be performed only after all A/V equipment and components within Division 27 have been completely installed to ensure all components have been properly integrated with each other as needed.

3.3. EQUIPMENT INSTALLATION, TESTING, AND ACCEPTANCE

A. Any required system programming (by CoM-IT or Contractor) shall be completed prior to doing any installation testing and acceptance.

B. It is the sole responsibility of the Contractor to notify CoM-IT no less than two (2) weeks in advance of completing the installation to coordinate all final testing of the completed system.

C. Wall Mounts:
   1. Wall mounts shall be securely fastened to the wall and blocking per the manufacturer's supplied instructions and mounting hardware. Wall mounts shall be located horizontally and vertically on the designated wall as indicated in plans and details for each room receiving monitors.
   2. Monitors shall be securely installed on the wall mount.
   3. The mounting bracket shall be tested with the completed monitor and cable/cords properly installed. The completed installation and successful testing of the mounting bracket installation shall provide the following:
      a. All cords/cables are properly plugged in, excessive cable is bundled but not stretched tight, cords/cables are not pinched or impede the mounting brackets range of motion.
      b. Full range of motion in all directions as per the specifications above.

D. Monitor testing shall be part of the overall Division 27 installation of all A/V equipment and requirements. This shall include but not be limited to the following:
   1. Remote control is fully functional at each monitor location
      a. A single remote is used and properly programmed to control monitors, IPTV cable boxes and other devices as needed.
         i. Controls on/off/volume and other related functions as a TV with an IP Cable Box.
         ii. Controls various input modes as a monitor as described in other Division 27 specifications.
         iii. Works with other video/audio feeds as described in other Division 27 specifications.

2. Monitor (each location) functions in all modes and inputs as designated in the contract documents.
    a. Test with Polycom system
    b. Test with portable devices (laptop, etc)

E. The IP Cable Box shall be tested at each location installed. Troubleshoot and re-test as necessary. Contact Owners Representative if a bad unit is suspected for immediate replacement.

F A completed and accepted installation shall pass all of the above tests for each location where equipment will be installed.

G. The warranty period for the completed and accepted installation shall not begin until the date of the accepted general contract. The Contractor shall coordinate this date with the General Contractor.

END OF SECTION

SECTION 27 41 43
AUDIO-VIDEO CONFERENCING (POLYCOM)
"FOR REFERENCE ONLY"

PART 1 – GENERAL

1.1. SUMMARY

A. These specifications describe the materials, equipment, and installation requirements to install a fully integrated, audio-video conferencing system (Polycom) currently in use by the City of Madison (Owner).

B. The Contractor shall be responsible for verifying equipment cabling requirements, locations, and coordination with the General Contractor and all other necessary trades as needed for a complete installation.

1.2. RELATED SPECIFICATIONS AND REFERENCES

A. The Contractor shall be responsible for reviewing all other specifications for requirements associated with the complete installation of A/V Accessories associated with this specification. This includes but is not limited to the following:

1. 01 31 23 Project Management Web Site
2. 01 33 23 Submittals
3. 27 05 00 Basic Communication Systems Requirements
4. 27 41 23 Audio-Visual Accessories

B. The Contractor shall be familiar with all Polycom best practice guides for system design and component placement. The Contractor shall be responsible for reviewing all plans and providing written notification to the Architect and owner in the event the plan set is in error.

1.3. RELATED DRAWINGS

A. Refer to all Electrical drawings for locations of distribution panels and equipment as it relates to standard line voltage locations.

B. Refer to all Technical drawings for locations of Polycom and other related audio visual equipment.

C. Refer to Architectural floor plans and details for information relating to equipment shelves, wall location, and blocking requirements.

1.4. CONTRACTOR QUALIFICATIONS

A. The Contractor shall be a certified in all of the following aspects associated with the complete installation of the specified Polycom system:

1. Polycom Platinum Solution Advisor in the Polycom Certified/Specialized Partner Program.

1.5. AREAS OF RESPONSIBILITY

A. The Owner and City of Madison Information Technology Department (CoM-IT) shall be responsible for all the following:

1. Review the plans and Polycom Best Practice Requirements for each installation with the Contractor.
2. Order & purchase all major Polycom components in quantities per the comprehensive list generated by the Contractor. Provide estimated delivery dates to the Contractor with confirmation of orders. The Owner and CoM-IT shall be responsible for the following major Polycom components:

a. Codecs, by owner
b. Cameras, by owner
c. Microphones, by owner

3. The CoM-IT shall be responsible for programming the Polycom codecs.
4. The Owner shall not be responsible for ancillary equipment required to complete the installation.

B. The General Contractor (GC) shall be responsible for the following:
1. Coordinating progress scheduling with the Contractor for all A/V related equipment.
2. Coordinating scheduling with the Owner for the timely purchase of equipment.
3. Receiving all A/V equipment delivered to the construction site and notifying the Contractor and Owner of its arrival.
4. Providing dry and secure storage for all A/V equipment until installed.

C. The Contractor shall be responsible for the following:
1. The Contractor shall review with CoM-IT the plans and Polycom Best Practice Requirements for each installation. The Contractor shall provide a comprehensive list of major components and quantities to be ordered/purchased by the Owner.
2. Coordinating/reporting installation progress with the GC, Owner, and CoM-IT.
3. See other division 27 specifications for additional A/V installation requirements.
a. Connector cables, connector ends, and cable ties

D. The following equipment shall be provided by the contractor under the A/V specification and drawings as noted to complete the Polycom installation:
1. Speakers: Pre-assembled baffle with white perforated steel grille and speaker assembly. Equip with 8" loudspeaker with 10-ounce magnet, universal matching transformer for 25 or 70 volt system with a minim of five secondary transformer taps. Provide matching back box and tile bridge.

1.7. WARRANTY

A. The Contractor shall warrant for one year the complete installation of cabling to equipment and components associated with this contract and installation. Contractors warranty shall be in the form of a written letter on company letterhead referring to the contract information, dates of installation and acceptance, signed by an authorized representative of the Contractors Company.
1. The Contractors warranty shall include but not be limited to the following:
a. Transportation to and from the location as often as needed during the warranty period.
b. All labor and materials necessary to properly and thoroughly trouble shoot the system.

PART 2 - PRODUCTS

2.1. GENERAL

A. The Contractor shall be responsible for providing all cable, boxes, conduit required to complete the Polycom installations.

PART 3 - EXECUTION

3.1. CONTRACTOR COORDINATION

A. The Contractor shall coordinate with the General Contractor (GC) and all other trade contractors as needed for the installation of the cabling for the Polycom system. Coordination shall include a pre-installation meeting during rough-in to ensure blocking, power outlets, and data outlets are properly located.

B. The contractor shall coordinate with the GC, Owner, Architect, and CoM IT a pre-installation walk through to verify all equipment locations including but not limited wall mounting locations, ceiling mounting locations, and floor outlet connections where applicable.

3.2. EQUIPMENT MOUNTING

A. All other plans and specifications shall apply to equipment mounting. In general terms:
1. The Electrical Contractor shall be responsible for all line voltage outlets
2. The Data Cabling contractor shall be responsible for all data and A/V cable boxes and wiring in support of the Polycom system
3. The Polycom Contractor shall be responsible for the installation of all Polycom component cabling.

3.3. CONDUITS AND WIRING

A. General Conduit and wiring shall be provided as per 3.2.A.2. and 3.2.A.3. above.

B. All excess cabling shall be properly bundled using Velcro cable straps only.

3.4. INSTALLATION TESTING AND ACCEPTANCE

A. It is the sole responsibility of the Contractor to notify CoM IT no less than two (2) weeks in advance of completing the installation to coordinate all final testing of the completed system.

B. The Contractor and CoM IT shall test each Polycom installation to ensure the installed components work per the specifications.

1. All installed components shall be inspected as follows:
    a. Excess cabling has been neatly wrapped with Velcro wire wraps and are properly stored
2. Each Polycom installation at the project site shall be tested with an offsite Polycom installation to ensure that all the following performance measures have been achieved:
    a. All network connectivity is complete and installed properly.
    b. Video output (may be one or more monitors)
    c. Refer to Specification 27 41 23 Audio-Visual Accessories for additional testing procedures of Polycom systems (identified in item 2.2.E. above) with A/V integrated equipment.

C. A completed and accepted installation shall pass all the above tests for each installed Polycom location.

D. The warranty period for the completed and accepted installation shall not begin until the date of the accepted general contract. The Contractor shall coordinate this date with the General Contractor.

END OF SECTION

SECTION 28 05 00
BASIC ELECTRONIC SAFETY AND SECURITY SYSTEM REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Basic Safety and Security System Requirements (herein referred to Security) specifically applicable to Division 28 sections, in addition to Division 1 - General Requirements.

1.2 SCOPE OF WORK

A. This Specification and the accompanying drawings govern the work involved in furnishing, installing, testing and placing into satisfactory operation the security systems as shown on the drawings and specified herein.

B. Each Contractor shall provide all new materials as indicated in the schedules on the drawings, and/or in these specifications, and all items required to make their portion of the security systems a finished and working system.

C. Description of systems include but are not limited to the following:

1. Electronic Access Control System
2. Video Surveillance
3. Fire Detection and Alarm
4. Low Voltage Security Wiring (less than +120VAC) as specified and required for proper system control and communications.
5. All associated electrical backboxes, conduit, miscellaneous cabling, and power supplies required for proper system installation and operation as defined in the “Suggested Matrix of Scope Responsibility”.
6. Firestopping of penetrations of fire-rated construction as described in Division 7.

1.3 WORK SEQUENCE

A. The successful Bidders shall be responsible for scheduling overtime hours for the following work:

B. Successful Bidders shall itemize all work and list associated hours and pay scale for each item.

1.4 DIVISION OF WORK BETWEEN ELECTRICAL AND SECURITY CONTRACTORS

A. Division of work is the responsibility of the Prime Contractor. Any scope of work described in the contract document shall be sufficient for including said requirement in the project. The Prime Contractor shall be solely responsible for determining the appropriate subcontractor for the described scope. In no case shall the project be assessed an additional cost for scope that is described in the contract documents. The following division of responsibility is a guideline based on typical industry practice.

B. Definitions:

1. "Electrical Contractor" as referred to herein refers to the Contractors listed in Division 26 of this Specification.

2. "Electrical Contractor" shall also refer to the Contractor listed in Division 28 of this specification when the "Suggested Matrix of Scope Responsibility" indicates the work shall be provided by the EC. Refer to the Contract Documents for the "Suggested Matrix of Scope Responsibility".

3. "Security Contractor" as referred to herein refers to the Contractors listed in Division 28 of this Specification.

4. Low Voltage Security Wiring: The wiring (less than 120VAC) associated with the Security Systems, used for analog and/or digital signals between equipment.

C. General:

1. The purpose of these Specifications is to outline typical Electrical and Security Contractor's work responsibilities as related to Security Systems including conduit, cable tray, power wiring and Low Voltage Security Wiring. The prime contractor is responsible for all divisions of work.

2. The exact wiring requirements for much of the equipment cannot be determined until the systems have been purchased and submittals are approved. Therefore, only known wiring, conduits, raceways, and electrical power as related to such items, is shown on the Security Drawings. Other wiring, conduits, raceways, junction boxes, and electrical power not shown on the Security Drawings but required for the successful operation of the systems shall be the responsibility of the Security Contractor and included in the Contractor's bid.

3. Where the Electrical Contractor is required to install conduit, conduit sleeves and/or power connections in support of Security systems, the final installation shall not begin until a coordination meeting between the Electrical Contractor and the Security Contractor has convened to determine the exact location and requirements of the installation.

4. Where the Electrical Contractor is required to install cable tray that will contain Low Voltage Security Wiring, the installation shall not begin until the Security Contractor has completed a coordination review of the cable tray shop drawing.

5. This Contractor shall establish Electrical and Security utility elevations prior to fabrication and installation. The Security Contractor shall cooperate with the Electrical Contractor and the determined elevations in accordance with the guidelines below. This Contractor shall coordinate utility elevations with other trades. When a conflict arises, priority shall be as follows:

   a. Lighting Fixtures
   b. Gravity Flow Piping, including Steam and Condensate
   c. Sheet Metal
   d. Electrical Busduct
   e. Cable Trays, including 12" access space
   f. Sprinkler Piping and other Piping
   g. Conduit and Wireway
   h. Open Cabling

D. Electrical Contractor's Responsibility:

1. Assumes all responsibility for all required conduit and power connections when shown on the "Suggested Matrix of Scope Responsibility" to be provided by the Electrical Contractor.

2. Assumes all responsibility for providing and installing cable tray.

3. Responsible for Security Systems grounding and bonding.

4. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

E. Security Contractor's Responsibility:

1. Assumes all responsibility for the Low Voltage Security Wiring of all systems, including cable support where open cable is specified.

2. Assumes all responsibility for all required backboxes, conduit and power connections not specifically shown as being provided by the Electrical Contractor on the "Suggested Matrix of Scope Responsibility."

3. Assumes all responsibility for providing and installing all ladder rack and other cable management hardware (as defined herein).

4. Responsible for providing the Electrical Contractor with the required grounding lugs or other hardware for each piece of Security equipment which is required to be bonded to the telecommunications ground system.

5. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

1.5 COORDINATION DRAWINGS

A. Definitions:

1. Coordination Drawings: A compilation of the pertinent layout and system drawings that show the sizes and locations, including elevations, of system components and required access areas to ensure that no two objects will occupy the same space.

a. Mechanical trades shall include, but are not limited to, mechanical equipment, ductwork, fire protection systems, plumbing piping, medical gas systems, hydronic piping, steam and steam condensate piping, and any item that may impact coordination with other disciplines.

b. Electrical trades shall include, but are not limited to, electrical equipment, conduit 1.5" and larger, conduit racks, cable trays, pull boxes, transformers, raceway, busway, lighting, ceiling-mounted devices, and any item that may impact coordination with other disciplines.

c. Technology trades shall include, but are not limited to, technology equipment, racks, conduit 1.5" and larger, conduit racks, cable trays, ladder rack, pull boxes, raceway, ceiling-mounted devices, and any item that may impact coordination with other disciplines.

d. Maintenance clearances and code-required dedicated space shall be included.

e. The coordination drawings shall include all underground, underfloor, in-floor, in chase, and vertical trade items.

2. The contractors shall use the coordination process to identify the proper sequence of installation of all utilities above ceilings and in other congested areas, to ensure an orderly and coordinated end result, and to provide adequate access for service and maintenance.

B. Participation:

1. The contractors and subcontractors responsible for work defined above shall participate in the coordination drawing process.

2. One contractor shall be designated as the Coordinating Contractor for purposes of preparing a complete set of composite electronic CAD coordination drawings that include all applicable trades, and for coordinating the activities related to this process. The Coordinating Contractor for this project shall be the Mechanical Contractor.

   a. The Coordinating Contractor shall utilize personnel familiar with requirements of this project and skilled as draftspersons/CAD operators, competent to prepare the required coordination drawings.

3. Electronic CAD drawings shall be submitted to the Coordinating Contractor for addition of work by other trades. IMEG will provide electronic file copies of ventilation drawings for contractor's use if the contractor signs and returns an "Electronic File Transfer" waiver provided by IMEG. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings.

C. Drawing Requirements:

1. The file format and file naming convention shall be coordinated with and agreed to by all contractors participating in the coordination process and the Owner.

   a. Scale of drawings:

      1) General plans: 1/4 Inch = 1 '-0" (minimum).

      2) Mechanical, electrical, communication rooms, and including the surrounding areas within 10 feet: 1/2 Inch = 1'-0" (minimum).

      3) Shafts and risers: 1/2 Inch = 1'-0" (minimum).

      4) Sections of shafts and mechanical and electrical equipment rooms: 1/4 Inch = 1 '-0" (minimum).

      5) Sections of congested areas: 1/2 Inch = 1'-0" (minimum).

2. Ductwork layout drawings shall be the baseline system for other components. Ductwork layout drawings shall be modified to accommodate other components as the coordination process progresses.

3. There may be more drawings required for risers, top and bottom levels of mechanical rooms, and shafts.

4. The minimum quantity of drawings will be established at the first coordination meeting and sent to the A/E for review. Additional drawings may be required if other areas of congestion are discovered during the coordination process.

D. General:

1. Coordination drawing files shall be made available to the A/E and Owner's Representative. The A/E will only review identified conflicts and give an opinion, but will not perform as a coordinator.

2. A plotted set of coordination drawings shall be available at the project site.

3. Coordination drawings are not shop drawings and shall not be submitted as such.

4. The contract drawings are schematic in nature and do not show every fitting and appurtenance for each utility. Each contractor is expected to have included in his/her bid sufficient fittings, material, and labor to allow for adjustments in routing of utilities made necessary by the coordination process and to provide a complete and functional system.

5. The contractors will not be allowed additional costs or time extensions due to participation in the coordination process.

6. The contractors will not be allowed additional costs or time extensions for additional fittings, reroutings or changes of duct size, that are essentially equivalent sizes to those shown on the drawings and determined necessary through the coordination process.

7. The A/E reserves the right to determine space priority of equipment in the event of spatial conflicts or interference between equipment, piping, conduit, ducts, and equipment provided by the trades.

8. Changes to the contract documents that are necessary for systems installation and coordination shall be brought to the attention of the A/E.

9. Access panels shall preferably occur only in gypsum board walls or plaster ceilings where indicated on the drawings.

   a. Access to mechanical, electrical, technology, and other items located above the ceiling shall be through accessible lay-in ceiling tile areas.

   b. Potential layout changes shall be made to avoid additional access panels.

   c. Additional access panels shall not be allowed without written approval from the A/E at the coordination drawing stage.

   d. Providing additional access panels shall be considered after other alternatives are reviewed and discarded by the A/E and the Owner's Representative.

   e. When additional access panels are required, they shall be provided without additional cost to the Owner.

10. Complete the coordination drawing process and obtain sign off of the drawings by all contractors prior to installing any of the components.

11. Conflicts that result after the coordination drawings are signed off shall be the responsibility of the contractor or subcontractor who did not properly identify their work requirements, or installed their work without proper coordination.

12. Updated coordination drawings that reflect as-built conditions may be used as record documents.

1.6 QUALITY ASSURANCE

A. Qualifications:

1. Only products of reputable manufacturers as determined by the Architect/Engineer will be acceptable.

2. Each Contractor and their subcontractors shall employ only workers who are skilled in their respective trades and fully trained. All workers involved in the installation, termination, testing, and placing into operation electronic security devices shall be individually trained by the manufacturer.

3. The Contractor shall be experienced in all aspects of this work and shall be required to demonstrate direct experience on recent systems of similar type and size.

4. The Contractor shall own and maintain tools and equipment necessary for successful installation and testing of electronic security devices and have personnel adequately trained in the use of such tools and equipment.

B. Compliance with Codes, Laws, Ordinances:

1. This Contractor shall conform to all requirements of the City of Madison Codes, Laws, Ordinances and other regulations having jurisdiction over this installation.

2. In the event there are no local codes having jurisdiction over this job, the current issue of the National Electrical Code shall be followed.

3. If there is a discrepancy between the codes and regulations having jurisdiction over this installation, and these specifications, the codes and regulations shall determine the method or equipment used.

4. If the Contractor notes, at the time of bidding, any parts of the drawings and specifications which are not in accordance with the applicable codes or regulations, he shall inform the Architect/Engineer in writing, requesting a clarification. If there is insufficient time to follow this procedure, he shall submit with the proposal, a separate price required to make the system shown on the drawings comply with the codes and regulations.

5. Verify the installation environment prior to purchasing or installing any cable. Cable installed in a plenum environment shall be appropriately rated. Bring all discrepancies between the contract documents and installation conditions to the attention of the Architect/Engineer prior to purchase or installation.

6. All changes to the system made after the letting of the contract, in order to comply with the applicable codes or the requirements of the Inspector, shall be made by the Contractor without cost to the Owner.

C. Permits, Fees, Taxes, Inspections:

1. Procure all applicable permits and licenses.

2. Abide by all applicable laws, regulations, ordinances, and other rules of the State or Political Subdivision wherein the work is done, or as required by any duly constituted public authority.

3. Pay all applicable charges for such permits or licenses that may be required.

4. Pay all applicable fees and taxes imposed by the State, Municipal and/or other regulatory bodies.

5. Pay all charges arising out of required inspections due to codes, permits, licenses or as otherwise may be required by an authorized body.

6. Pay all charges arising out of required contract document reviews associated with the project and as initiated by the Owner or authorized independent agency/consultant.

7. All equipment, and materials shall be as approved or listed by the following: (Unless approval or listing is not applicable to an item by all acceptable manufacturers.)

   a. Factory Mutual
   b. Underwriters' Laboratories, Inc.

D. Examination of Drawings:

1. The drawings for the Security Systems work are diagrammatic, intended to convey the scope of the work and to indicate the general arrangements and locations of equipment etc., and the approximate sizes of equipment.

2. Contractor shall determine the exact locations of equipment and the exact routing of cabling so as to best fit the layout of the job. Scaling of the drawings will not be sufficient or accurate for determining this layout. Where a specific route is required, such route will be indicated on the drawings.

3. Where job conditions require reasonable changes in indicated arrangements and locations, such changes shall be made by the Contractor at no additional cost to the Owner.

4. If an item is either shown on the drawings, called for in the specifications or required for proper operation of the system, it shall be considered sufficient for including same in this contract.

5. The determination of quantities of material and equipment required shall be made by the Contractor from the drawings. Schedules on the drawings and in the specifications, are completed as an aid to the Contractor but where discrepancies arise, the greater number shall govern.

6. Where words "provide", "install", or "furnish" are used on the drawings or in the specifications, it shall be taken to mean, to furnish, install and terminate completely ready for operation, the items mentioned.

E. Electronic Media/Files:

1. Construction drawings for this project have been prepared utilizing Revit.

2. Contractors and Subcontractors may request electronic media files of the contract drawings and/or copies of the specifications. Specifications will be provided in PDF format.

3. Upon request for electronic media, the Contractor shall complete and return a signed “Electronic File Transmittal” form provided by IMEG.

4. If the information requested includes floor plans prepared by others, the Contractor will be responsible for obtaining approval from the appropriate Design Professional for use of that part of the document.

5. The electronic contract documents can be used for preparation of shop drawings and as-built drawings only. The information may not be used in whole or in part for any other project.

6. The drawings prepared by IMEG for bidding purposes may not be used directly for ductwork layout drawings or coordination drawings.

7. The use of these CAD documents by the Contractor does not relieve them from their responsibility for coordination of work with other trades and verification of space available for the installation.

8. The information is provided to expedite the project and assist the Contractor with no guarantee by IMEG as to the accuracy or correctness of the information provided. IMEG accepts no responsibility or liability for the Contractor’s use of these documents.

F. Field Measurements:

1. Before ordering any materials, this Contractor shall verify all pertinent dimensions at the job site and be responsible for their accuracy.

1.7 SUBMITTALS

A. Submittals shall be required for the following items, and for additional items where required elsewhere in the specifications or on the drawings.

1. Submittals list:

Referenced Specification Section	Submittal Item
28 13 00	Electronic Access Control
28 23 00	Video Surveillance

B. General Submittal Procedures: In addition to the provisions of Division 1, the following are required:

1. Transmittal: Each transmittal shall include the following:

   a. Date
   b. Project title and number
   c. Contractor's name and address
   d. Division of work (e.g., plumbing, heating, ventilating, etc.)
   e. Description of items submitted and relevant specification number
   f. Notations of deviations from the contract documents
   g. Other pertinent data

2. Submittal Cover Sheet: Each submittal shall include a cover sheet containing:

   a. Date
   b. Project title and number
   c. Architect/Engineer
   d. Contractor and subcontractors' names and addresses
   e. Supplier and manufacturer's names and addresses
   f. Division of work (e.g., plumbing, heating, ventilating, etc.)
   g. Description of item submitted (using project nomenclature) and relevant specification number
   h. Notations of deviations from the contract documents
   i. Other pertinent data
   j. Provide space for Contractor's review stamps

3. Composition:

   a. Submittals shall be submitted using specification sections and the project nomenclature for each item.

   b. Individual submittal packages shall be prepared for items in each specification section. All items within a single specification section shall be packaged together where possible. An individual submittal may contain items from multiple specifications sections if the items are intimately linked (e.g., pumps and motors).

   c. All sets shall contain an index of the items enclosed with a general topic description on the cover.

4. Content: Submittals shall include all fabrication, erection, layout, and setting drawings; manufacturers' standard drawings; schedules; descriptive literature, catalogs and brochures; performance and test data; wiring and control diagrams; dimensions; shipping and operating weights; shipping splits; service clearances; and all other drawings and descriptive data of materials of construction as may be required to show that the materials, equipment or systems and the location thereof conform to the requirements of the contract documents.

5. Contractor's Approval Stamp:

   a. The Contractor shall thoroughly review and approve all shop drawings before submitting them to the Architect/Engineer. The Contractor shall stamp, date and sign each submittal certifying it has been reviewed.

b. Unstamped submittals will be rejected.

c. The Contractor's review shall include, but not be limited to, verification of the following:

1) Only approved manufacturers are used.
2) Addenda items have been incorporated.
3) Catalog numbers and options match those specified.
4) Performance data matches that specified.
5) Electrical characteristics and loads match those specified.
6) Equipment connection locations, sizes, capacities, etc. have been coordinated with other affected trades.
7) Dimensions and service clearances are suitable for the intended location.
8) Equipment dimensions are coordinated with support steel, housekeeping pads, openings, etc.
9) Constructability issues are resolved (e.g., weights and dimensions are suitable for getting the item into the building and into place, sinks fit into countertops, etc.).

d. The Contractor shall review, stamp and approve all subcontractors' submittals as described above.

e. **The Contractor's approval stamp is required on all submittals. Approval will indicate the Contractor's review of all material and a complete understanding of exactly what is to be furnished. Contractor shall clearly mark all deviations from the contract documents on all submittals. If deviations are not marked by the Contractor, then the item shall be required to meet all drawing and specification requirements.**

6. Submittal Identification and Markings:

a. The Contractor shall clearly mark each item with the same nomenclature applied on the drawings or in the specifications.

b. The Contractor shall clearly indicate the size, finish, material, etc.

c. Where more than one model is shown on a manufacturer's sheet, the Contractor shall clearly indicate exactly which item and which data is intended.

d. All marks and identifications on the submittals shall be unambiguous.

7. Schedule submittals to expedite the project. Coordinate submission of related items.

8. Identify variations from the contract documents and product or system limitations that may be detrimental to the successful performance of the completed work.

9. Reproduction of contract documents alone is not acceptable for submittals.

10. Incomplete submittals will be rejected without review. Partial submittals will only be reviewed with prior approval from the Architect/Engineer.

11. Submittals not required by the contract documents may be returned without review.

12. The Architect/Engineer's responsibility shall be to review one set of shop drawing submittals for each product. If the first submittal is incomplete or does not comply with the drawings and/or specifications, the Contractor shall be responsible to bear the cost for the Architect/Engineer to recheck and handle the additional shop drawing submittals.

13. Submittals shall be reviewed and approved by the Architect/Engineer **before** releasing any equipment for manufacture or shipment.

14. Contractor's responsibility for errors, omissions or deviation from the contract documents in submittals is not relieved by the Architect/Engineer's approval.

C. Electronic Submittal Procedures:

1. Distribution: Email submittals as attachments to all parties designated by the Architect/Engineer, unless a web-based submittal program is used.

2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.

3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.

4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

a. Submittal file name: 28 XX XX.description.YYYYMMDD
b. Transmittal file name: 28 XX XX.description.YYYYMMDD

5. File Size: Electronic file size shall be limited to a maximum of 4MB. Larger files shall be transmitted via a pre-approved method.

D. Paper Copy Submittal Procedures:

1. Paper copies are acceptable where electronic copies are not provided.

2. Each set shall be bound in a three-ring binder or presentation binder. Copies that are loose or in pocket folders are not acceptable.

1.8 SCHEDULE OF VALUES

A. The requirements herein are in addition to the provisions of Division 1.

B. Format:

1. Use AIA Document Continuation Sheets G703 or another similar form approved by the Owner and Architect/Engineer.
2. Submit in Excel format.
3. Support values given with substantiating data.

C. Preparation:

1. Itemize work required by each specification section and list all providers. All work provided by subcontractors and major suppliers shall be listed on the Schedule of Values. List each subcontractor and supplier by company name.

2. Break down all costs into:

a. Material: Delivered cost of product with taxes paid.
b. Labor: Labor cost, excluding overhead and profit.

1.9 CHANGE ORDERS

A. The requirements herein are in addition to the provisions of Division 1.

B. A detailed material and labor takeoff shall be prepared for each change order, along with labor rates and markup percentages. Change orders with inadequate breakdown will be rejected.

C. Change order work shall not proceed until authorized.

1.10 EQUIPMENT SUPPLIERS' INSPECTION

A. The following equipment shall not be placed in operation until a representative of the manufacturer has inspected the installation and certified that the equipment is properly installed and that the equipment is ready for operation:

1. Firestopping, including mechanical firestop systems.

1.11 PRODUCT DELIVERY, STORAGE, HANDLING & MAINTENANCE

A. Exercise care in transporting and handling to prevent damage to fixtures, equipment and materials.

B. Store materials on the site so as to prevent damage.

C. Keep fixtures, equipment and materials clean, dry and free from harmful conditions.

1.12 NETWORK / INTERNET CONNECTED EQUIPMENT

A. These specifications may require certain equipment or systems to have network, Internet and/or remote access capability ("Network Capability"). Any requirement for Network Capability shall be interpreted only as a functional capability and is not to be construed as authority to connect or enable any Network Capability. Network Capability may only be connected or enabled with the express written consent of the Owner.

1.13 WARRANTY

A. The requirements herein are in addition to the provisions of Division 1.

B. At a minimum, provide a one (1) year warranty for all equipment, materials, and workmanship. Individual specifications sections within Division 28 may require additional warranty requirements for specific equipment or systems.

C. The warranty period for the entire installation described in this Division of the specifications shall commence on the date of substantial completion unless a whole or partial system or any separate piece of equipment or component is put into use for the benefit of any party other than the installing contractor with prior written authorization. In this instance, the warranty period shall commence on the date when such whole system, partial system or separate piece of equipment or component is placed in operation and accepted in writing by the Owner or their representative.

D. Warranty requirements shall extend to correction, without cost to the final user, of all work and/or equipment found to be defective or nonconforming to the contract documents. The Contractor shall bear the cost of correcting all damage resulting from such defects or nonconformance with contract documents exclusive of repairs required as a result of improper maintenance or operation, or of normal wear as determined by the Architect/Engineer.

1.14 INSURANCE

A. This Contractor shall maintain insurance coverage as set forth in Division 1 of these specifications.

1.15 MATERIAL

A. Where several manufacturers' names are given, the first named manufacturer constitutes the basis for job design and establishes the equipment quality required to be used in this contract.

B. Equivalent equipment manufactured by the other named manufacturers may be used. Contractor shall ensure that all items submitted by these other manufacturers meets all requirements of the drawings and specifications and fits in the allocated space. The Architect/Engineer shall make the final determination of whether a product is equivalent.

C. Any material, article or equipment of other unnamed manufacturers which will adequately perform the services and duties imposed by the design and is of a quality equal to or better than the material, article or equipment identified by the drawings and specifications may be used if approval is secured **in writing** from the Architect/Engineer not later than ten (10) days prior to the bid opening date. The Contractor bears full responsibility for the unnamed manufacturers equipment adequately meeting the intent of design. The Architect/Engineer may reject manufacturer at time of shop drawing submittal. The Contractor assumes all costs incurred by other trades on the project as a result of changes necessary to accommodate the offered material, equipment or installation method.

D. Should this Contractor be unable to secure approval from the Architect/Engineer for other unnamed manufacturers as outlined above, this Contractor may list voluntary add or deduct prices for alternate materials on the bid form. These items will not be used in determining the low bidder. Should a voluntary alternate material be accepted, This Contractor shall assume all costs that may be incurred as a result of using the offered material, article or equipment necessitating extra expense on This Contractor or on the part of other Contractors whose work is affected.

PART 2 - PRODUCTS

2.1 REFER TO INDIVIDUAL SECTIONS

PART 3 - EXECUTION

3.1 JOBSITE SAFETY

A. Neither the professional activities of the Architect/Engineer, nor the presence of the Architect/Engineer or his or her employees and subconsultants at a construction site, shall relieve the Contractor and any other entity of their obligations, duties and responsibilities including, but not limited to, construction means, methods, sequence, techniques or procedures necessary for performing, superintending or coordinating all portions of the work of construction in accordance with the contract documents and any health or safety precautions required by any regulatory agencies. The Architect/Engineer and his or her personnel have no authority to exercise any control over any construction contractor or other entity or their employees in connection with their work or any health or safety precautions. The Contractor is solely responsible for jobsite safety. The Architect/Engineer and the Architect/Engineer's consultants shall be indemnified and shall be made additional insureds under the Contractor's general liability insurance policy.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Installation of all conduit and cabling shall comply with Sections 26 05 33 and 26 05 13. Additional conduit requirements described within this Division shall be supplemental to the requirement described in Section 26 05 33. Should conflicts exist between the two Divisions the more stringent (more expensive material and labor) condition shall prevail until bidding addendum or construction clarification or RFI can be submitted and responded to. In no case shall the Contractor carry the least stringent condition in the pricing.

B. It is the Contractor's responsibility to survey the site and include all necessary costs to perform the installation as specified.

C. All cables and devices installed in damp or wet locations, including any underground or underslab location, shall be listed as suitable for use in such environments. Follow manufacturer's recommended installation practices for installing cables and devices in damp or wet locations. Any cable or device that fails as a result of being installed in a damp or wet location shall be replaced at the Contractor's expense.

3.3 FIELD QUALITY CONTROL

A. General:

1. Refer to specific Division 28 sections for further requirements.

2. The Contractor shall conduct all tests required and applicable to the work both during and after construction of the work.

3. The necessary instruments and materials required to conduct or make the tests shall be supplied by the Contractor who shall also supply competent personnel for making the tests who has been schooled in the proper testing techniques.

4. In the event the results obtained in the tests are not satisfactory, This Contractor shall make such adjustments, replacements and changes as are necessary and shall then repeat the test or tests which disclose faulty or defective work or equipment, and shall make such additional tests as the Architect/Engineer or code enforcing agency deems necessary.

B. Protection of cable from foreign materials:

1. It is the Contractor's responsibility to provide adequate physical protection to prevent foreign material application or contact with any cable type. Foreign material is defined as any material that would negatively impact the validity of the manufacturer's performance warranty. This includes, but is not limited, to overspray of paint (accidental or otherwise), drywall compound, or any other surface chemical, liquid or compound that could come in contact with the cable, cable jacket or cable termination components.

2. Application of foreign materials of any kind on any cable, cable jacket or cable termination component will not be accepted. It shall be the Contractor's responsibility to replace any component containing overspray, in its entirety, at no additional cost to the project. Cleaning of the cables with harsh chemicals is not allowed. This requirement is regardless of the PASS/FAIL test results of the cable containing overspray. Should the manufacturer and warrantor of the structured cabling system desire to physically inspect the installed condition and certify the validity of the structured cabling system (via a signed and dated statement by an authorized representative of the structured cabling manufacturer), the Owner may, at their sole discretion, agree to accept said warranty in lieu of having the affected cables replaced. In the case of plenum cabling, in addition to the statement from the manufacturer, the Contractor shall also present to the Owner a letter from the local Authority Having Jurisdiction stating that they consider the plenum rating of the cable to be intact and acceptable.

3.4 PROJECT CLOSEOUT

A. Refer to the Division 1 Section: PROJECT CLOSEOUT for requirements. The following paragraphs supplement the requirements of Division 1.

B. Final Jobsite Observation:

1. The Architect/Engineer will not perform a final jobsite observation until the project is ready. This is not dictated by schedule, but rather by completeness of the project.

2. Refer to the end of Section 27 05 00 for a "STATEMENT INDICATING READINESS FOR FINAL JOBSITE OBSERVATION."

3. The Contractor shall sign this form and return it to the Architect/Engineer so that the final observation can commence.

C. Before final payment will be authorized, this Contractor must have completed the following:

1. Submitted operation and maintenance manuals to the Architect/Engineer for review.

2. Submitted bound copies of approved shop drawings.

3. Record documents including edited drawings and specifications accurately reflecting field conditions, **inclusive** of all project revisions, change orders, and modifications.

4. Submitted a report stating the instructions given to the Owner's representative complete with the number of hours spent in the instruction. The report shall bear the signature of an authorized agent of This Contractor and shall be signed by the Owner's representative as having received the instructions.

5. Submitted testing reports for all systems requiring final testing as described herein.

6. Submitted start-up reports on all equipment requiring a factory installation inspection and/or start.

7. Provide spare parts, maintenance, and extra materials in quantities specified in individual specification sections. Deliver to project site, submit receipt to Architect/Engineer prior to final payment being approved.

3.5 OPERATION AND MAINTENANCE MANUALS

A. Refer to the Division 1 Section: OPERATION AND MAINTENANCE MANUALS for requirements. The following paragraphs supplement the requirements of Division 1.

B. General:

1. Provide an electronic copy of the O&M manuals as described below for Architect/Engineer's review and approval. The electronic copy shall be corrected as required to address the Architect/Engineer's comments. Once corrected, electronic copies and paper copies shall be distributed as directed by the Architect/Engineer.

2. Approved O&M manuals shall be completed and in the Owner's possession prior to Owner's acceptance and at least 10 days prior to instruction of operating personnel.

C. Electronic Submittal Procedures:

1. Distribution: Email the O&M manual as attachments to all parties designated by the Architect/Engineer.

2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.

3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.

4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

   a. O&M file name: O&M.div28.contractor.YYYYMMDD
   b. Transmittal file name: O&Mtransmittal.div28.contractor.YYYYMMDD

5. File Size: Electronic file size shall be limited to a maximum of 4MB. Larger files shall be divided into files that are clearly labeled as "1 of 2", "2 of 2", etc.

6. Provide the Owner with an approved copy of the O&M manual on compact discs (CD), digital video discs (DVD), or flash drives with a permanently affixed label, printed with the title "Operation and Maintenance Instructions", title of the project and subject matter of disc/flash drive when multiple disc/flash drives are required.

7. All text shall be searchable.

8. Bookmarks shall be used, dividing information first by specification section, then systems, major equipment and finally individual items. All bookmark titles shall include the nomenclature used in the construction documents and shall be an active link to the first page of the section being referenced.

D. Operation and Maintenance Instructions shall include:

1. Title Page: Include title page with project title, Architect, Engineer, Contractor, all subcontractors, and major equipment suppliers, with addresses, telephone numbers, website addresses, email addresses and point of contacts. Website URLs and email addresses shall be active links in the electronic submittal.

2. Table of Contents: Include a table of contents describing specification section, systems, major equipment, and individual items.

3. Copies of all final approved shop drawings and submittals. Include Architect's/Engineer's shop drawing review comments. Insert the individual shop drawing directly after the Operation and Maintenance information for the item(s) in the review form.

4. Copy of final approved test and balance reports.

5. Copies of all factory inspections and/or equipment startup reports.

6. Copies of warranties.

7. Schematic wiring diagrams of the equipment that have been updated for field conditions. Field wiring shall have label numbers to match drawings.

8. Dimensional drawings of equipment.

9. Capacities and utility consumption of equipment.

10. Detailed parts lists with lists of suppliers.

11. Operating procedures for each system.

12. Maintenance schedule and procedures. Include a chart listing maintenance requirements and frequency.

13. Repair procedures for major components.

14. List of lubricants in all equipment and recommended frequency of lubrication.

15. Instruction books, cards, and manuals furnished with the equipment.

3.6 INSTRUCTING THE OWNER'S REPRESENTATIVE

A. Adequately instruct the Owner's designated representative or representatives in the maintenance, care, and operation of the complete systems installed under this contract.

B. Provide verbal and written instructions to the Owner's representative or representatives by FACTORY PERSONNEL in the care, maintenance, and operation of the equipment and systems.

C. Contractor shall make a DVD video recording of instructions to the Owner while explaining the system so additional personnel may view the instructions at a later date. The video recording shall be the property of the Owner.

D. The Architect/Engineer shall be notified of the time and place for the verbal instructions to be given to the Owner's representative so that their representative can be present if desirable.

E. Refer to the individual specification sections for minimum hours of instruction time for each system.

F. Operating Instructions:

1. The Contractor is responsible for all instructions to the Owner and/or Owner's operating staff on the security systems.

2. If the Contractor does not have Engineers and/or Technicians on staff that can adequately provide the required instructions on system operation, performance, troubleshooting, care and maintenance, they shall include in the bid an adequate amount to reimburse the Owner for the Architect/Engineer to perform these services.

3.7 SYSTEM COMMISSIONING

A. The security systems included in the construction documents are to be complete and operating systems. The Architect/Engineer will make periodic job site observations during the construction period. The system start-up, testing, configuration, and satisfactory system performance is the responsibility of the Contractor. This shall include all calibration and adjustments of electrical equipment controls, equipment settings, software configuration, troubleshooting and verification of software, and final adjustments that may be required.

B. All operating conditions and control sequences shall be simulated and tested during the start-up period.

C. The Contractor, subcontractors, and equipment suppliers are expected to have skilled technicians to insure that the system performs as designed. If the Architect/Engineer is requested to visit the job site for the purpose of trouble shooting, assisting in the satisfactory start-up, obtaining satisfactory equipment operation, resolving installation and/or workmanship problems, equipment substitution issues or unsatisfactory system performance, including call backs during the warranty period through no fault of the design; the Contractor shall reimburse the Owner on a time and material basis for services rendered at the Architect/Engineer's standard hourly rates in effect at the time the services are requested. The Contractor shall be responsible for making payment to the Owner for services required that are product, installation or workmanship related. Payment is due within 30 days after services are rendered.

3.8 RECORD DOCUMENTS

A. Refer to the Division 1 Section: PROJECT CLOSEOUT for requirements. The following paragraphs supplement the requirements of Division 1.

B. Mark specifications to indicate approved substitutions, change orders, and actual equipment and materials used.

C. This Contractor shall maintain at the job site, a separate and complete set of Security Drawings which shall be clearly and permanently marked and noted in complete detail any changes made to the location and arrangement of equipment or made to the Technology Systems and wiring as a result of building construction conditions or as a result of instructions from the Architect or Engineer. All Change Orders, RFI responses, Clarifications and other supplemental instructions shall be marked on the documents. Record documents that merely reference the existence of the above items are not acceptable. Should This Contractor fail to complete Record Documents as required by this contract, This Contractor shall reimburse Architect/Engineer for all costs to develop record documents that comply with this requirement. Reimbursement shall be made at the Architect/Engineer's hourly rates in effect at the time of work.

D. The above record of changes shall be made available for the Architect and Engineer's examination during any regular work time.

E. Upon completion of the job, and before final payment is made, This Contractor shall give the marked-up drawings to the Architect/Engineer.

3.9 ADJUST AND CLEAN

A. Contractor shall thoroughly clean all equipment and systems prior to the Owner's final acceptance of the project.

B. Contractor shall clean all foreign paint, grease, oil, dirt, labels, stickers, and other foreign material from equipment.

C. Contractor shall remove all rubbish, debris, etc., accumulated during the Contractor's operations from the premises.

3.10 SPECIAL REQUIREMENTS

A. In accordance with LEED EQc4.1, Low-Emitting Materials - Adhesives and Sealants, all adhesives and sealants used on the interior of the building must comply with the following requirements:

1. Adhesives, sealants and sealant primers must comply with South Coast Air Quality Management District (SCAQMD) Rule #1168.

2. Aerosol adhesives must comply with Green Seal Standard for Commercial Adhesives GS-36 requirements in effect on October 19, 2000.

3.11 CONSTRUCTION WASTE MANAGEMENT

A. This Contractor shall comply with all construction and demolition waste disposal and recycling requirements outlined in LEED MRc2: Construction Waste Management (follow latest edition at the time of bidding or as referenced in these specifications).

1. This Contractor shall coordinate with the General Contractor to develop and implement a construction waste management plan that, at a minimum, identifies the materials to be diverted from disposal and whether the materials will be sorted on-site or co-mingled.

2. The Contractor shall track waste disposal and recycling efforts throughout the construction process for all materials associated with this Contractor’s scope of work. The Contractor shall provide this information to the General Contractor so that it can be incorporated with similar information from all other contractors for the project.

a. Calculations for waste and recycled material can be done by weight or volume, but they must be consistent throughout the project. The Contractor shall coordinate with the General Contractor to establish the preferred calculation method and report the results accordingly.

b. Excavated soil and land-clearing debris do not count towards the waste disposal or recycled material.

3. At a minimum, 50% 75% of the construction and demolition debris for this project must be recycled or salvaged.

END OF SECTION

SECTION 28 13 00
ACCESS CONTROL SYSTEM (KEYSCAN)

PART 1 - GENERAL

1.1. SUMMARY

A. The City of Madison Information Technology Department has been assisting other City agencies with standardizing facilities through the use of access cards, key fobs, and punch pads. All hardware is installed locally at the facility while software controls access to various doors remotely.

B. These specifications describe the materials, equipment, and installation requirements to install an integrated, computerized access control and alarm monitoring system utilized by the City of Madison Information Technology (CoM-IT) Department.

C. The ACS System Contractor shall be responsible for verifying equipment requirements, locations, and coordination with the General Contractor and all other necessary trades as needed for a complete installation.

1.2. RELATED SPECIFICATIONS

A. 01 31 23 Project Management Web Site
B. 01 33 23 Submittals
C. 08 71 00 Door Hardware
D. 27 05 00 Basic Communication Systems Requirements

1.3. RELATED DRAWINGS

A. Refer to all Electrical drawings for locations of distribution panels and equipment as it relates to standard line voltage locations.

B. Refer to all Technical drawings for locations of Access Control System (Keyscan) equipment.

C. Refer to the door hardware schedule and Architectural floor plans for information relating to door access locations and specific hardware requirements.

1.4. REFERENCES

A. The system shall comply with the standards, codes and regulations of the following regulatory bodies:
1. Underwriters Laboratories (UL) Std No. 294 – Access Control System Units
2. Canadian Standards Association (CSA) Std C22.2 No. 205-M1983 – Signal Equipment

3. CE Standards
    a. EN 55022 RF Emissions
    b. EN 55024 RF Immunity
    c. EN 60950-1 Equipment Safety
4. FCC Subpart B – RF Emissions
5. Industry Canada ICES 003 Emissions
6. RoHS

1.5. CONTRACTORS QUALIFICATIONS

A. The Contractor installing the ACS system shall:
1. Be a Certified Keyscan Enterprise Partner
2. Utilize installers who are Keyscan Enterprise Certified Technicians
3. Be based within 25 radial miles of the project location
4. Be able to provide 24/7/365 support during the warranty period of this project
5. Be able to respond and repair or replace most components within 4 hours of notification

1.6. SUBMITTALS

A. The Contractor shall provide a complete submittal package in a timely manner to allow sufficient review time prior to ordering the system components required for a complete installation. The contractor shall be solely responsible for any equipment, purchased/ordered/delivered that is not approved of during the submittal review process.

B. The complete submittal package shall include but not be limited to the following:
1. All certifications of the contractor and contractor's installation team. Certifications shall be current from the start of the contract through the end of the warranty period.
2. Cut sheets indicating, shop drawings, performance data, and other such information that will indicate the component being installed matches the component that was specified.
3. Cut sheets and shop drawing of Contractors recommendations for tags and labels.

1.7. WARRANTY

A. The Contractor shall warrant for one year the complete installation of equipment and components associated with this contract and installation. Contractors warranty shall be in the form of a written letter on company letterhead referring to the contract information, dates of installation and acceptance, signed by an authorized representative of the Contractors Company.
1. The Contractors warranty shall include but not be limited to the following:
    a. Transportation to and from the location as often as needed during the warranty period.
    b. All labor and materials necessary to properly and thoroughly trouble shoot the system.
    c. All fees associated with the shipping of any component that needs to be returned or supplied by the manufacturer for repair or replacement.
    d. All labor and materials required to remove, repair, replace, or re-install any component.

B. The Contractor shall also provide all manufacturers warranties/guarantees associated with installed components of the completed installation.

1.8. QUALITY ASURANCE

A. The Contractor shall be responsible for coordinating his/her Work with other trades and divisions as needed for a complete installation. This shall include pre-installation meetings for locating equipment, conduit, cabling, control devices, and other materials and equipment required by this installation.

B. The General Contractor (GC) shall be responsible for ensuring that all doors requiring controlled access are properly prepared and installed per the contract documents. The GC shall further be responsible for ensuring all project coordination, pre-installation meetings, submittals and other such project management responsibilities are conducted efficiently and according to the project specifications and schedules.

PART 2 - PRODUCTS

2.1. SYSTEM PRODUCTS OVERVIEW

A. The City of Madison Information Technology Department (CoM IT) owns and operates a fully licensed copy of the Keyscan Access Control System software.
1. The Keyscan Access Control System (ACS) provides controlled access to secured doors through the use of electronic door latches, proximity readers, control panels, and a proprietary software program.

2. The Keyscan software allows CoM-IT and the facility the Owner to customize multiple levels of access and system performance through any combination of the following:
    a. Calendar and time based lock/unlock controls
    b. Group access control for common personnel groups
    c. Individual access control for specialized access control
    d. Temporarily disable access control for a specified time period
    e. Remotely unlock/lock a door
    f. Lockdown a facility from one location
    g. Provide customizable alert notifications

2.2. EQUIPMENT AND COMPONENTS

A. The Contractor guarantees that all equipment and components shall be furnished new, undamaged, free of defects, and conform to the drawings and specifications of this contract. The contractor is solely responsible for replacing any damaged or defective item.

B. New ACS components on interior and exterior access doors shall be able to be integrated with the Owners existing Keyscan system.

2.3. DISTRIBUTION SUPPLY PANEL (AC-DS-1)

A. AC-DS-1 brings line voltage into the ACS system with the following performance specifications:
    1. Input
        a. 115VAC, 60Hz, 1.45A
    2. Output
        a. Eight (8) PTC protected outputs
        b. 16VAC output
        c. 16VAC @ 10amp (175 VA) supply current (1.25 amp per device, 2.5 amp max.)
        d. Outputs rated @ 2.5 amp
        e. Main fuse rated @ 15 amp/32V
        f. Surge suppression
    3. Miscellaneous electrical information
        a. Operating temperature 0^{o} C to 49^{o}C ambient
        b. 81.89 BTU/hr
        c. System AC input VA requirement 166.75 AV
    4. Miscellaneous required features
        a. AC power LED indicators
        b. Illuminated master power disconnect circuit breaker with manual reset
    5. Agency Approvals
        a. UL 294 listed for Access Control System Units
        b. CUL listed-CSA Standard C22.2 No 205-M1983 Signal Equipment

B. AC-DS-1 shall be:
    1. Altronix, AL168175CB
    2. Pre-approved equal

2.4. POWER SUPPLY PANEL (AC-PS-1)

A. The AC-PS-1 brings line voltage from the AC-DS-1, reduces then distributes the voltage to the Access Security Panels (AC-SEC-1) with the following performance specifications:
    1. Input
        a. 115VAC, 60Hz, 1.9A
        b. Power supply input options
            i. One (1) common power input for ACM8 and lock power (factory installed)
            ii. Two (2) isolated power inputs; one (1) to power the ACM8 and one (1) for lock accessory power, (external power supply is required). Current is determined by the power supply connected, not to exceed a maximum of 10 amp total
        c. Eight (8) Access control System trigger inputs with the following options:
            i. Eight (8) normally open (NO) inputs
            ii. Eight (8) open collector inputs
            iii. Any combination of the above
    2. Output
        a. 12VDC or 24VDC @ 6 amp supply current

b. Eight (8) independently controlled outputs with the following options:
i. Eight (8) Fail-Safe and/or Fail-Secure power outputs
ii. Eight (8) form "C" 5 amp rated relay outputs
iii. Any combination of the above
c. Eight (8) auxiliary power outputs (un-switched)
d. Output fuses rated @ 3.5 amp
e. Filtered and electronically regulated outputs (built-in power supply).

3. Miscellaneous electrical information
a. Operating temperature 0^{o} C to 49^{o}C ambient
b. BTU/hr:
i. 12VDC = 36.85 BTU/hr
ii. 24VDC = 73.70 BTU/hr
c. ACM8 board main fuse is rated at 10 amp

4. Battery Backup
a. Built-in charger for sealed lead acid or gel type batteries
b. Power supply board maximum charge current 0.7 amp
c. Automatic switch over to stand-by battery when AC fails
d. Zero voltage drop when unit switches over to battery backup (AC failure condition)
e. Battery fail and battery presence supervision (form "C" contact)

5. Miscellaneous required features
a. Fire Alarm disconnect (latching or non-latching) is individually selectable for any or all of the eight (8) outputs.
b. Fire Alarm disconnect input options:
i. Normally open (NO) or normally closed (NC) dry contact input
ii. Polarity reversal input for FACP signaling circuit
c. Alarm output relay indicates that FACP input is triggered (form "C" contact rated @ 1 amp 28VDC)
d. Short circuit and thermal overload protection
e. AC fail supervision (form "C" contact)
f. Red LEDs indicate outputs are triggered (relays energized)
g. Green LED indicates FACP disconnect is triggered
h. AC input and DC output LED indicators
i. Enclosure accommodates up to two (2) 12AH batteries

6. Agency Approvals
a. UL 294 listed for Access Control System Units
b. CUL listed-CSA Standard C22.2 No 205-M1983 Signal Equipment

B. AC-PS-1 shall be:
1. Altronix, AL600ULACM
2. Pre-approved equal

2.5. SECURITY PANEL (AC-SEC-1)

A. The AC-SEC-1 distributes the reduced voltage and control wiring to/from each door with an access control device.
B. AC-SEC-1 shall be:
1. Keyscan CA8500 – 8 Reader Access Control Panel
C. The AC-SEC-1 shall be provided, located and mounted by the Contractor in room B001A (MC-1).

2.6. DOOR CONTROL DEVICES

A. The Contractor shall be responsible for verifying the Door Control Device (DCD) quantities and locations with the door hardware schedule.
B. DCD shall be:
1. Keyscan K-KPR – Keyscan Proximity Reader/Keypad, this reader accepts swipe monitoring of cards, key bobs, and other such devices as well as accepting personal identification numbers (PINs)
i. Plan designation = AC-CR1-W

2.7. DOOR CONTROL CABLES

A. The following cables are required for a complete installation of the ACS, per controlled door, as follows:
1. One (1) 22/6 shielded cable, required; to DCD
2. One (1) 18/2 un-shielded cable, required; lock power

3. One (1) 22/2 un-shielded cable, required; door contact
4. One (1) 22/4 un-shielded cable, required but not used; for future request to exit sensors

B. At the Contractors option he/she may run a manufactured cable bundle containing all four (4) cables listed above. It shall be the sole responsibility of the contractor to appropriately size the conduits for the installation.

PART 3 - EXECUTION

3.1. COOPERATION OF THE ACS CONTRACTOR

A. The Contractor shall be required to coordinate with all trades for a complete and timely installation. This includes attending all pre-installation meetings where equipment locations, conduit locations, and control devices will be installed or may be in conflict with the installation of other trades. The Contractor shall be solely responsible for any additional cost required for removing/replacing/modifying any completed work by other trades because the installation was not properly coordinated.

B. The Contractor shall coordinate with the Owners Representative from City IT for all information necessary to complete the installation and integration with the Owners existing hardware and software.

C. The Contractor shall verify with the appropriate Owners Representative for mounting heights of all hardware and equipment prior to installation. This shall be completed at a pre-installation walk through prior to rough-in.

D. The Contractor shall coordinate with the Owner's Representative from City IT to verify all requirements for all access controlled doors are properly coordinated and understood prior to roughing in the installation.

3.2. GENERAL EQUIPMENT MOUNTING

A. All ACS equipment shall be mounted to the 3/4" AC fire rated plywood panels provided and installed by the General Contractor. Contractor shall tape out all equipment prior to mounting to insure adequate space is allotted for the complete installation per the riser diagrams including all related conduits and cables.

B. All equipment shall be neatly arranged so as to meet or exceed the manufacturer's recommended working space around each component.

C. Equipment to be installed on plywood mounting panels shall include but not be limited to the following:
1. Distribution Service Panel (AC-DS-1)
2. Power Supply Panel (AC-PS-1)
3. Access Control Panel (AC-SEC-1)
4. All required conduits, and boxes for line voltage

3.3. GENERAL CONDUITS AND WIRING

A. This section shall apply to both the ACS Contractor and the Electrical Contractor. The following division of responsibilities shall apply:
1. The Electrical Contractor shall be responsible for furnishing, installing, and connecting all conduits, connectors, conductors, and other related materials associated with providing line voltage to the ACS system as follows:
   a. Providing an 110V, 15A, dedicated circuit from the designated distribution panel to AC-DS-1 as described in Section 2.3 above.
   b. Providing line voltage from AC-DS-1 to AC-PS-1 as described in Section 2.4 above.
2. The ACS Contractor shall be responsible for furnishing installing, and connecting all conduits, connectors, conductors and other related materials required to complete the installation of the low voltage wiring and door controller cabling.

B. All conduits shall be properly sized for the number of wires or wire bundles being pulled through the conduit. The Contractor shall verify with the manufacturer the recommended fill rate by conduit size and shall not exceed the recommendations.

C. The contractor shall neatly lay out all conduits in such a fashion so as to minimize bending, crossovers, etc.

D. Bends, pull boxes, and pull points shall be sized and located as per all applicable codes and standards for the number of wires or wire bundles in the bend, pull box, pull point.

E. CAT6 cables from each AC-SEC-1 shall be neatly run in cable management equipment supplied and installed by the cabling contractor or conduits supplied and installed by the ACS Contractor as needed. The switch to be used for all ACS equipment shall be located in Telecom Room B001A. Cables shall be labeled on both ends per the cabling specification.

F. The General Contractor and the ACS Contractor shall ensure the following Emergency Access requirements are properly installed and operational prior to the final Madison Fire Department inspection for occupancy.
1. CoM IT shall provide a minimum of six (6) swipe cards to each installed Knox Box for emergency entrance. The cards shall be appropriately coded for entry at all controlled access doors.

3.4. EQUIPMENT IDENTIFICATION AND LABLEING

A. The Contractor shall provide and install all equipment identification and labeling to the following specifications.
   1. Tags and labels shall be permanent rigid plastic or metal tags with engraved or machine stamped lettering. Hand written self-stick or metal hand stamped tags will not be accepted.
   2. The Contractor shall work out the labeling scheme for doors with City IT, Owner, and Architect prior to ordering any labels or tags.
   3. The Contractor shall provide all labels and tags associated with this specification. This shall include the line voltage feed to each AC-DS-1 from the electrical distribution panel.

B. Panels and Boxes
   1. All panels and boxes shall be labeled on the outside cover that readily identifies the panel/box as a "Distribution Supply", "Power Supply", "Access Control Panel", etc. An associated number shall also be on each tag and the number "1" shall be used even if there is only one of that type panel/box.
   2. Access Control Panels shall have a card index inside the front cover of each door indicating the controller number, door number, and door location being served by that panel.

C. Conduits
   1. Line voltage from electrical distribution panels shall have conduits labeled on both ends as follows:
      a. At the distribution panel the line voltage conduit shall be labeled with the system supplied, and the ACS distribution supply panel number.
      b. In the Telecommunications Room the line voltage conduit label shall indicate the distribution panel and circuit number(s) controlling the supply line.
   2. Conduits between Access Control Panels and the controlled doors shall be labeled on both ends as follows:
      a. In the Telecommunications Room each conduit shall labeled with the door number(s) being supplied.
      b. Above the finished ceiling where the conduit is exposed prior to going into the wall space that serves the door the conduit shall be labeled with the Door Control Panel and Controller number associated with the door being served.
      c. If the conduit size is reduced as control cabling is supplied to doors along the run each change is conduit size shall be re-labeled as noted in 2.b. above.
   3. Conduits between equipment and components in the Telecommunications Room do not need to be identified.

3.5. INSTALLATION TESTING AND ACCEPTANCE

A. The CoM IT and the Owner shall be responsible for completing all software programming associated with the installation of this contract prior to the completion of the installation of the system components. It is the sole responsibility of the Contractor to notify the Owner no less than two (2) weeks in advance of completing the installation that all codes and time setting shall be prepared for final installation and testing.

B. The Contractor, CoM IT, and the Owner shall test each access control point with swipe cards and PINs to insure the door unlocks.

C. CoM IT shall test each door using the existing fully integrated software. This shall include but not be limited to the following:
   1. Remotely lock/unlock the doors
   2. Verify time clock feature works for locking doors
   3. Verify swipe cards and PINs work on all doors
   4. Verify emergency entrance cards for knox boxes work on all doors for the areas served.

D. A completed and accepted installation shall pass all of the above tests for all controlled access points.

E. The warranty period for the completed and accepted installation shall not begin until the date of the accepted general contract. The Contractor shall coordinate this date with the General Contractor.

END OF SECTION

SECTION 28 20 00
ELECTRONIC SURVEILLANCE
"FOR REFERENCE ONLY"

PART 1 – GENERAL

1.1. SUMMARY

A. The City of Madison requires video surveillance of interior and exterior areas of the Fire Station #14 as indicated in the Technology plan sheets.

B. This specification shall identify major equipment components and accessories required for a complete video surveillance installation. It does not include materials such as cables, boxes, connectors, conduit, supports and other ancillary equipment required to complete the installation.

C. For the purposes of this specification the term Contractor shall refer to the person(s) responsible for installing the Electronic Surveillance System and may or may not be the same contractor installing other Division 27 and 28 related equipment. Other contractors having related work shall be referred to by full title (Electrical Contractor).

1.2. RELATED SPECIFICATIONS

A. 01 31 23 Project Management Web Site
B. 01 33 23 Submittals
C. 01 78 23 Operation and Maintenance Data
D. 01 78 36 Warranties
E. 01 78 39 As-Built drawings
F. All Division 27 specifications that may apply to this installation

1.3. AREAS OF RESPONSIBILITY

A. The General Contractor (GC) shall be responsible for ensuring all of the following:
   1. Coordinate all Contractor related work with the construction schedule.
   2. Coordinate all required Work with the Contractor and other trades during pre-installation meetings and resolve installation issues as needed.

B. The Contractor shall be responsible for all of the following:
   1. For all equipment ordering and purchasing, setup, configuration, and testing of equipment being installed under this specification and connected to City of Madison-Information Technology (CoM-IT) servers and equipment.
      a. Include any mounting brackets required for mounting camera equipment to the structure.
      b. The Contractor shall be responsible for the bridge supports identified in Section 2.2.C below.
   2. Verification of Owner installation requirements prior to installing equipment and accessories.
   3. Provide all ancillary materials and equipment required to complete the installation.

C. CoM-IT shall be responsible for all of the following:
   1. The CoM-IT shall be responsible for the Exacq-Vision system licenses.
   2. Provide connection to servers and other hardware necessary to bring installed equipment on line.
   3. Assist in final testing of equipment and equipment functions installed under this specification.

1.4. SUBMITTALS

A. The Contractor is not required to provide submittals for products provided by the City of Madison.

1.4. WARRANTY

A. The Contractor shall warrant for one year the complete installation of equipment and components associated with this contract and installation. Contractors warranty shall be in the form of a written letter on company letterhead referring to the contract information, dates of installation and acceptance, signed by an authorized representative of the Contractors Company.
   1. The Contractors warranty shall include but not be limited to the following:
      a. Transportation to and from the location as often as needed during the warranty period.
      b. All labor and materials necessary to properly and thoroughly trouble shoot the system.
      c. All fees associated with the shipping of any component that needs to be returned or supplied by the manufacturer for repair or replacement.
      d. All labor and materials required to remove, repair, replace, or re-install of any component.

B. The Contractor shall also provide all manufacturers warranties/guarantees associated with installed components of the completed installation.

PART 2 - PRODUCTS

2.1. EXTERIOR SURVEILLANCE LOCATIONS

A. The exterior camera shall be a high quality outdoor ready PTZ (pan/tilt/zoom) camera as follows:
   1. AXIS Communications, PTZ Dome Network Camera with the minimum requirements listed below:
      a. HDTV minimum 1920 x 1080p
      b. Certified compatible with Exacq Technologies Exacq-Vision Video Management System
      c. 3 year AXIS extended warranty option

B. Exterior camera mounting accessories shall of high quality and rated for outdoor environments.
   1. AXIS Communications, models as required for the installation of the above noted camera and locations as indicated in the plans and specifications, any substitutions in camera placement to be reviewed and approved by City of Madison Department of Information Technology, with all standard features including the following:
      a. 3 year AXIS extended warranty option

2.2. INTERIOR SURVEILLANCE LOCATIONS

A. The interior camera shall be a high quality indoor ready PTZ (pan/tilt/zoom) camera as follows:
   1. AXIS Communications, PTZ Dome Network Camera with the minimum requirements listed below:
      a. HDTV minimum 1920 x 1080p
      b. Certified compatible with Exacq Technologies Exacq-Vision Video Management System
      c. 3 year AXIS extended warranty option

B. Interior camera mounting accessories shall of high quality and rated for indoor environments,
   1. AXIS Communications, models as required for the installation of the above noted camera and locations as indicated in the plans and specifications, any substitutions in camera placement to be reviewed and approved by City of Madison Department of Information Technology, with all standard features including the following:
      a. 3 year AXIS extended warranty option
      b. Surface mount as per plans
      c. Drop ceiling mount as per plans

C. All drop ceiling mount locations shall include tile bridge supports
   1. ERICO, SCMKC Security Camera Mounting Kit
   2. Pre-approved equal

PART 3 - EXECUTION

3.1. COOPERATION OF THE CONTRACTOR

A. All line voltage installations that may be required under this specification shall be installed by the Electrical Contractor. Power shall come from the nearest power panel where the equipment is being installed. Label boxes with panel and circuit number for future reference. Installation shall include any fire stopping as required by code.

B. Data cables shall be installed by the Cabling Contractor as required for this installation. Data cables shall come from the nearest Telecom Room where the equipment is being installed. Installation shall include any fire stopping as required by code.

C. The Contractor shall install all security cameras, mounting hardware, boxes and other equipment necessary for a complete installation of the surveillance system.

3.2. EXTERIOR INSTALLATIONS

A. Provide and install all camera mounting hardware, fastening hardware and anchors as needed for a strong, secure and stable installation as necessary for the building materials being mounted to.

B. Provide and install a high grade clear silicone sealant around all mounting hardware.

C. Provide sufficient cable and install a drip loop if cable is exposed outside of the mounting hardware.

D. Label camera end of data cable with permanent data tag indicating switch location connection id.

E. Label switch end of data cable with permanent data tag indicating camera location.

3.3. INTERIOR INSTALLATIONS

A. Provide and install all camera mounting hardware, fastening hardware and anchors as needed for a strong, secure and stable installation as necessary for the building materials being mounted to.

B. Install tile bridge supports at all drop ceiling locations.

C. Label camera end of data cable with permanent data tag indicating switch location connection id.

D. Label switch end of data cable with permanent data tag indicating camera location.

3.4. INSTALLATION TESTING AND ACCEPTANCE

A. Any required system programming (by Contractor) shall be completed prior to doing any installation testing and acceptance.

B. It is the sole responsibility of the Contractor to notify CoM-IT no less than two (2) weeks in advance of completing the installation to coordinate all final testing of the completed system.

C. The Contractor and CoM-IT shall test each surveillance camera installation to ensure the installed components work per the specifications.

1. All installed components shall be inspected as follows:
    a. All connections are tight, exterior installations are weather proof with clear silicone sealant.
    b. All components are clean and free of dust, finger prints and other general dirt.
    c. Camera lenses and domes are clean and free of lint, dust and finger prints.
    d. Cameras are free to rotate.
    e. All network connectivity is complete and installed properly.
2. Each camera installation at the project site shall be tested from an offsite computer to ensure all pan/tilt/zoom features, focus and other functions are fully operational.

E. A completed and accepted installation shall pass all of the above tests for each installed camera location.

F. The warranty period for the completed and accepted installation shall not begin until the date of the accepted general contract. The Contractor shall coordinate this date with the General Contractor.

END OF SECTION

SECTION 28 31 00
FIRE ALARM AND DETECTION SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fire alarm and detection systems

1.2 QUALITY ASSURANCE

A. Manufacturer: Company specializing in smoke detection and fire alarm systems with ten years' experience.

B. Installer: A factory-authorized licensed electrical or security contractor with five years' experience in the design, installation and maintenance of fire alarm systems by that manufacturer.

C. Qualifications: The person managing/overseeing the preparation of shop drawings and the system installation/programming/testing shall be trained and certified by the system manufacturer and shall be Fire Alarm Certified by NICET, minimum Level 2. This person's name and certification number shall appear on the start-up and testing reports.

1.3 REFERENCES

A. NFPA 70 - National Electrical Code

B. NFPA 72 - National Fire Alarm and Signaling Code

C. NFPA 101 - Life Safety Code

D. UL 2017 – General Purpose Signaling Devices and Systems

1.4 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 26 05 00 and as noted below.

1. Failure to comply with all of the following and all of the provisions in 26 05 00 will result in the shop drawing submittal being rejected without review.

2. Failure to submit the fire alarm without all requirements fulfilled in a single comprehensive submittal will be grounds to require a complete resubmittal.

B. Provide product catalog data sheets as shop drawings.

1. Provide a product catalog data sheet for each item shown on the Electrical Symbols List and for each piece of equipment that is not shown on the drawings, but required for the operation of the system.

2. Where a particular Electrical Symbols List item has one or more variations (such as those denoted by subscripts, etc.) a separate additional product catalog data sheet shall be provided for each variation that requires a different part number to be ordered. The corresponding Electrical Symbols List symbol shall be shown on the top of each sheet.

3. Where multiple items and options are shown on one data sheet, the part number and options of the item to be used shall be clearly denoted.

C. Submit CAD floor plans as shop drawings:

1. The complete layout of the entire system, device addresses, auxiliary equipment, and manufacturer's wiring requirements shall be shown.

2. A legend or key shall be provided to show which symbols shown on the submittal floor plans correspond with symbols shown on the Contract Documents.

D. With regard to all fire alarm circuits, provide the following: manufacturer's wiring requirements (manufacturer, type, size, etc.) and voltage drop calculations.

E. Provide installation and maintenance manuals under provisions of Section 26 05 00.

F. Submit manufacturer's certificate that system meets or exceeds specified requirements.

G. Provide information on the system batteries as follows: total battery capacity, total capacity used by all devices on this project, total available future capacity.

H. Submit photocopy proof of NICET certification of the person overseeing the preparation of drawings and installation/testing.

I. When required to comply with local or state regulatory reviews, the fire alarm submittal shall have a Professional Engineer's stamp and signature of the state in which the project is completed. NOTE: The Architect/Engineer cannot stamp and seal submittal drawings not prepared under their supervision.

1.5 EXTRA MATERIALS

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

1. Provide quantity equal to 2 percent (2%) of amount of each type installed, but no less than two (2) units of each type.

a. Smoke and heat detectors, manual pull stations, duct smoke detectors, monitor modules, control modules and relays.

b. Notification appliances: Speakers, speaker strobes, and strobes.

2. Keys: The installing contractor shall collect all equipment spare keys provided with each lockable or resettable device/cabinet [minimum of one (1) set each] and shall turn over to the Owner upon completion.

3. All spare parts shall be housed in metal cabinet labeled "Fire Alarm Spare Parts."

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 26 05 00.

B. Store and protect products under provisions of Section 26 05 00.

1.7 REGULATORY REQUIREMENTS

A. System: UL or FM Global listed.

B. Conform to requirements of NFPA 101.

C. Conform to requirements of Americans with Disabilities Act (ADA).

D. Conform to UL 864 Fire Alarm, UL 1076 Security, UL2017 General Signaling, and UL 2572 Mass Notification Communications.

1.8 SYSTEM DESCRIPTION

A. Performance Statement: This specification section and the accompanying fire alarm specific design documents describe the minimum material quality, required features, and operational requirements of the system. These documents do not convey every wire that must be installed and every equipment connection that must be made. Based on the equipment described and the performance required of the system, as presented in these documents, the Vendor and the Contractor are solely responsible for determining all wiring, programming and miscellaneous equipment required for a complete and operational system.

B. This section of the specifications includes the furnishing, installation and connection of the microprocessor controlled, intelligent reporting, fire alarm equipment required to form a complete coordinated system that is ready for operation. It shall include, but is not limited to, alarm initiating devices, control panels, auxiliary control devices, annunciators, power supplies, and wiring as indicated on the drawings and specified herein.

C. Fire Alarm System: NFPA 72; Automatic and manual fire alarm system, non-coded, analog-addressable with automatic sensitivity control of certain detectors, multiplexed signal transmission.

D. System Supervision: Provide electrically supervised system, with supervised Signal Line Circuit (SLC) and Notification Appliance Circuit (NAC). Occurrence of single ground or open condition in initiating or signaling circuit places circuit in TROUBLE mode. Component or power supply failure places system in TROUBLE mode.

E. Alarm Reset: Key-accessible RESET function resets alarm system out of ALARM if alarm initiating circuits have cleared.

F. Lamp Test: Manual LAMP TEST function causes alarm indication at each zone at fire alarm control panel and at annunciator panels.

G. Drawings: Only device layouts and some equipment have been shown on the contract drawings. Wiring and additional equipment to make a complete and functioning system has not been shown, but shall be submitted on the shop drawings.

1.9 PROJECT RECORD DOCUMENTS

A. Submit documents under the provisions of Section 26 05 00.

B. Include location of end-of-line devices.

C. Provide a CAD drawing of each area of the building (minimum scale of 1/16” = 1’-0”) showing each device on the project and its address. The devices shall be shown in their installed location and shall be labeled with the same nomenclature as is used in the fire alarm panel programming.

D. Submit test results of sound pressure level (dBA) and intelligibility (STI) with the rooms tested designated on the floor plan. Notification devices shall have the tap wattage designated.

1.10 OPERATION AND MAINTENANCE DATA

A. Submit data under provisions of Section 26 05 00.

B. Include operating instructions, and maintenance and repair procedures.

C. Include results of testing of all devices and functions.

D. Include manufacturer’s representative's letter stating that system is operational.

E. Include the CAD floor plan drawings.

F. Include shop drawings as reviewed by the Architect/Engineer and the local Authority Having Jurisdiction.

1.11 WARRANTY

A. Provide one (1) year warranty on all materials and labor from Date of Substantial Completion.

B. Warranty requirements shall include furnishing and installing all software upgrades issued by the manufacturer during the one (1) year warranty period.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Simplex
B. Notifier by Honeywell
C. Edwards - EST
D. Siemens Fire Safety
E. Gamewell - FCI

2.2 [FAP-#]: FIRE ALARM CONTROL PANEL (FAP)

A. Control Panel: Modular, power-limited electronic design. Provide wall-mounted enclosure as shown on plans. Enclosure shall be minimum 0.060 steel with provisions for electrical conduit connections into the sides and top. The door shall provide a key lock and shall include a glass or other transparent opening for viewing of all indicators.

B. Each Signaling Line Circuit (SLC loop) shall not be loaded over 80% of the maximum device capacity. For example, in the minimum system capacity column listed below, if the fire alarm manufacturer's system capacity of analog sensors per loop is 99 devices, then no more than 79 devices shall be wired on that loop. The minimum system capacity shall be as follows:

Minimum Total Addressable Points:	500
Minimum Total SLC loops (including board, ready for field connections):	2

C. Signal Line Circuit Board (SLC):

1. Each board shall communicate directly with each addressable analog sensor and binary input to determine normal, alarm, or trouble conditions. Analog signals would be used for automatic test and determination of maintenance requirements.

2. Each board shall contain its own microprocessor and shall be provided to monitor addressable inputs and to control addressable outputs (addressable relays). The board shall communicate and provide power to all devices on its loop over a single pair of wires, except where 4-wire devices require a separate power circuit.

3. Class B, Style 4: Circuits NOT capable of transmitting an alarm beyond the location of the fault condition. Wiring of outgoing and return conductors is permitted to be run in the same conduit or cable.

4. SLC for addressable devices with less than 50 devices can be Class A or B, and more than 50 devices shall be Class A.

D. Notification Appliance Circuit (NAC) Board:

1. Each board shall contain its own microprocessor and shall be provided to control each notification appliance circuit. The board shall communicate and provide power to all devices on its loop.

2. Class B, Style Y: Circuits NOT capable of transmitting an alarm beyond the location of the fault condition. Wiring of outgoing and return conductors is permitted to be run in the same conduit or cable.

E. Central Processing Unit:

1. The central processing unit (CPU) shall communicate with the monitor and control all other modules in the panel. Removal, disconnection or failure of any control panel module shall be detected and reported to the CPU.

2. The CPU shall execute all control-by-event programs for specific action to be taken if a designated situation is detected in the system. A real-time system clock for time annotations on the display and printer shall be included.

3. All power for the unit shall be supervised and supplied by the FAP.

F. Display:

1. The board shall provide all controls and indicators used by the system operator and may also be used to program all control panel parameters.

2. The board shall provide an alphanumeric array for display of custom alphanumeric labels for all addressable points. It shall also provide indicators for AC Power, System Alarm, System Trouble, Display Trouble and Signal Silence.

3. Displayed descriptions of addressable points shall include actual room names/numbers selected by the Owner. This information shall be obtained prior to programming. Room names/numbers shown on floor plans shall not be used.

4. The board shall provide a touch key-pad with control capability to command all system functions and entry of any alphanumeric information. Twenty different passwords with four levels of security shall be supported to prevent unauthorized manual control or programming.

G. Memory: The CPU and display interface board shall be augmented by non-volatile field programmable memory. EPROM memory will also be allowed provided the memory is burned in with minimum expansion capability equal to the total system capacity of the panel. Memory shall not be lost upon primary and secondary power failure.

H. Power Supply:

1. Input power shall be 120 VAC, 60 Hertz. Output power shall be as noted on the device specifications and drawings. Each component of the fire alarm system requiring 120 VAC input power shall be served from a dedicated emergency branch circuit. Provide two #12 conductors and one #12 ground in 3/4" conduit to a dedicated 20A/1P circuit breaker with a red handle and a manufacturer's standard handle lock-on device. Identify/label breaker and branch circuit in accordance with NFPA requirements and Specification Section 26 05 53.

2. Adequate to supply 125% of all control panel and peripheral power needs as well as 125% of power required for all external audio-visual devices. The power supply may be increased as needed by adding additional modular expansion power supplies. Over-current protections shall be provided on all power outputs.

3. All power supplies shall be designed and installed to meet UL and NFPA requirements for power-limited operation on all external initiating and indicating circuits.

4. The power supply shall provide integral charger for use with internal batteries. Battery capacity shall be sufficient for operation of the entire system for 24 hours in a non-alarm state followed by alarm mode for 15 minutes, plus 25% spare capacity for future devices.

I. Surge Protection:

1. All fire alarm control panels, NAC panels, etc. shall be provided with a surge protection device (SPD). The SPD shall be UL listed to Standard 1449 Rev 3. The unit should be clearly labeled in accordance with Identification Section 26 05 53. The SPD shall have thermal fuses to protect against fire in short circuit conditions. The unit shall provide visual indication that the unit is protecting and functioning.

2. Any communications or signaling circuits associated with the fire alarm system, which leave or enter a facility, shall be provided with a surge protection device. The devices shall be as recommended by the fire alarm system manufacturer.

J. Dual Digital Communicator:

1. Provide dual phone line interface capable of fire alarm notification to the local fire department, fire protection agency, or monitoring service. Communicator shall report in SIA and most major communication formats, with the capability of transmitting each device address point in a format compatible with the central station receiver.

2. Communicator shall be fully supervised and shall operate on loop start phase lines ahead of the building PBX system.

3. Communicator shall be FCC registered. Contractor shall provide two RJ31X jacks.

4. Approvals: UL listed - UL 864/NFPA 72, FM approved.

5. The communicator shall be provided integral to the fire alarm panel as furnished by the fire alarm panel manufacturer. If the panel construction requires a separate unit, the unit shall be as manufactured by Silent Knight, Ademco, or fire alarm panel manufacturer approved equal.

K. IP-GSM Digital Cellular Fire Communicator:

1. Provide digital internet / cellular phone interface capable of fire alarm notification to the local fire department, fire protection agency, or monitoring service. Monitoring fees and initial connection charges are not part of this project.

2. Contractor to provide connection of communicator to Owner's Ethernet 10/100 Base network connection. Wiring shall be in 1" conduit.

3. Communicator shall convert fire alarm control panel phone outputs into Ethernet packets and transmit to GSM networks in area including 2G, 3G and 4G.

4. Communication shall include system status including individual addressable device status, power loss, low battery and earth fault, and 24 hour test signal.

2.3 SIGNALING LINE CIRCUIT DEVICES

A. **[FA-120]:** Smoke Detectors:

1. Analog Photoelectric Type Sensor: Shall use the photoelectric principle to measure smoke density and send data to the control panel representing the analog level of smoke density measured.

2. Each smoke detector shall connect directly to an SLC loop.

3. Each detector shall be mounted, where shown on the drawings, on a twist-lock base with all mounting hardware provided. Provide a two-piece head/base design.

4. Each detector shall have a manual switching means to set the internal identifying code (address) of that detector, which the control panel shall use to identify its address with the type of sensor connected.

5. Dual alarm and power indicators shall be provided that flash under normal conditions and remain continuous under alarm or trouble conditions. Remote indicator terminals shall be provided. Provide a remote LED indicator device if detector is not visible from a floor standing position.

6. A test means shall be provided to simulate an alarm condition.

7. Where operation is noted as required below 32ºF and/or above 120ºF, a conventional device shall be installed with a unique monitor module located in the nearest available location with maintained temperatures between 32ºF and 120ºF.

8. Audible sounder detector base for sleeping room applications:

   a. The audible base shall sound an alarm in the local room in UL2017 operation and UL484 for general evacuation. The unit shall be programmable by the main control panel for the duration of operation.

   b. The audible sounder base shall sound Temporal 3 (fire) or Temporal 4 (CO alarm) and be at 75 dB at 10 feet.

9. A subscript is used to identify the device with a specific sequence of operation as follows: E=Elevator Recall, S=Sleeping/Patient Room, D=HVAC Control, A=Atrium, SW=Stairwell, CR=Computer Room, SD=Smoke Dampers, DH=Door Hold Release, FD= Fire Door Release, MP=Medical Procedure Room.

B. **[FA-121]:** Projected Beam Type Detectors:

1. This device shall utilize photoelectric analog smoke sensor technology. Provide with transmitter and associated receiver. Microprocessor-based detector shall provide a minimum of eight sensitivity levels, temperature and dirt compensation, and automatic gain control. Sensor to contain beam alignment adjustments and receiver calibration.

2. Detector shall connect directly to an SLC loop or shall be provided with multiple monitor modules, as required, to connect to the SLC loop and for monitoring alarm and trouble output contacts. The detector shall be provided complete with all mounting hardware provided and installed where indicated on the drawings.

3. Dual alarm and power indicators shall be provided that flash under normal conditions and remain continuous under alarm or trouble conditions. Remote indicator terminals shall be provided.

4. Provide with remote indicator panel providing LED indications of alarm and trouble.

C. **[FA-122]:** Duct Smoke Detectors:

1. Duct-type smoke detectors shall use the same analog photoelectric sensor technology, with the same features specified for standard smoke detectors, except with additional features as specified below.

2. Provide sampling tubes and mounting hardware to match the duct to which it is attached. Where the detector housing is larger than the duct height, the Contractor shall fabricate a mounting bracket for the detector and attach according to the fire alarm manufacturer's recommendations.

3. Provide a remote alarm LED indicator device (FA-240/241) if detector is not visible from a floor-standing position. If detector is located above a suspended ceiling, mount remote indicator in ceiling directly below detector with a white single-gang faceplate labeled: Duct Smoke Detector.

D. **[FA-123]** In-Duct Smoke Detectors:

1. Analog Photoelectric Type Sensor: Shall use the photoelectric principle to measure smoke density and send data to the control panel representing the analog level of smoke density measured.

2. Low Flow Type: Listed for use in duct with 0-2000 feet per minute velocity.

3. Each smoke detector shall connect directly to an SLC loop.

4. Each detector shall be mounted, where shown on the drawings, on a twist-lock base with all mounting hardware provided to match the duct application. Provide a two-piece head/base design.

5. Each detector shall have a manual switching means to set the internal identifying code (address) of that detector, which the control panel shall use to identify its address with the type of sensor connected.

6. Provide a remote LED indicator device (FA-240/241), mounted in ceiling directly below detector with a single-gang faceplate labeled: Duct Smoke Detector.

E. Manual Pull Stations:

1. Manual stations shall match the description on the drawings (refer to the General Electrical Equipment Schedule). The stations shall be mounted where shown on the drawings and be provided with all necessary mounting hardware. WG subscript indicates wire guard is required.

2. **[FA-130]**: Addressable, double action with plastic breakrod, reset key lock, semi-flush mount, red high abuse plastic or cast metal construction with white lettering.

3. **[FA-131]:** Addressable, double action with plastic breakrod, reset key lock, semi-flush mount, red high abuse plastic or cast metal construction with white lettering. Provide device with clear Lexan tamper resistant cover with integral 9V battery powered alarm that sounds when shield is lifted.

4. Manual stations shall connect directly to an SLC loop. Stations shall provide address setting means using rotary decimal or DIP switches.

5. Where operation is noted as required below 32ºF and/or above 120ºF, a conventional device shall be installed with a unique monitor module located in the nearest available location, with maintained temperatures between 32ºF and 120ºF.

F. Heat Detectors:

1. **[FA-140]:** Combination rate of rise and 135°F fixed temperature analog thermal type sensor. Factory programmed to alarm at 135ºF and at 15ºF per minute rate-of-rise. Sensor shall measure heat level and send data to the control panel representing the analog level of thermal measurement and rate-of-rise.

    a. A subscript is used to identify the device with a specific sequence of operation as follows: E=Elevator Shutdown.

2. **[FA-141]:** 200°F fixed temperature. Provide a remote addressable monitor module to interface with addressable system as shown on the plans.

3. Provide a two-piece head/base design, with a manual switching means to set the internal identifying code (address) of that detector, which the control panel shall use to identify its address with the type of sensor connected.

4. Heat detectors shall connect directly to SLC loops. Where fixed temperature or explosion proof detectors are used, one monitor module may be used to monitor all detectors in one room/area as shown on the drawings.

5. Detectors shall be mounted, where shown on the drawings, on a twist-lock base with all mounting hardware provided.

6. Provide a remote LED indicator device if detector is not visible from a floor-standing position.

7. Dual alarm and power indicators shall be provided that flash under normal conditions and remain continuous under alarm or trouble conditions. A connection for attachment of a remote indicator shall be provided.

8. A test means shall be provided to simulate an alarm condition.

9. Where operation is noted as required below 32°F and/or above 120°F, a conventional device shall be installed with a unique monitor module located in the nearest available location with maintained temperatures between 32°F and 120°F.

G. **[FA-150]:** Carbon Monoxide/Heat/Smoke Combination Detector:

1. Multi-criteria sensor for photoelectrical smoke sensing, heat and carbon monoxide (CO) detection. Carbon monoxide electrolytic sensing module shall provide toxic gas sensing to UL2034 and UL2075 standards.

2. The combined photoelectric smoke detection/heat/CO module shall have separate sensors that adjust the detection profile in response to the input from the sensors.

3. The combined photoelectric smoke detection / CO module shall have selectable modes of operation for OSHA compliant toxic gas sensing, enhanced fire sensing, and nuisance alarm reduction mode.

4. The detector shall use only one address on the SLC.

5. CO sensor cartridge element shall be field replaceable.

H. **[FA-151]:** Flame Detector:

1. Microprocessor based design. Ultraviolet and infrared type detector. Swivel mount. Provide with anti-contaminant air shields and a remote test switch located at the fire alarm control panel. Provide two addressable monitor modules for monitoring alarm and fault output contacts.

I. **[FA-160]:** Monitor Modules:

1. Monitor Module shall connect directly to an SLC loop and receive power from a separate 24 VDC circuit. It shall interface initiating devices with the control panel using Style D or Style B circuits. Contractor option: Use an interface module (2-wire operation) for Style B circuits connected to normally-open dry contacts, such as a flow switch.

2. The module shall be mounted in an enclosure located in an accessible service location as near as possible to the device(s) being monitored, or where shown on the drawings. All mounting hardware shall be provided.

3. The module shall supply the required power to operate the monitored device(s).

4. The module shall provide address setting means using rotary decimal or DIP switches.

J. **[FA-161]:** Addressable Relays:

1. Relay that represents an addressable control point used primarily for the control of auxiliary devices as indicated on the drawings. Contractor to provide additional slave relay(s), as required, rated for the electrical load being controlled (contractor to match voltage, amps, etc.).

2. Relay shall connect directly to an SLC loop and receive power from a separate 24 VDC circuit.

3. The relay shall be mounted in an enclosure located in an accessible service location as near as possible to the device(s) being controlled, unless otherwise shown on the drawings. All mounting hardware shall be provided.

4. The relay shall supply 24 VDC power to the device(s) being controlled, unless otherwise indicated on the drawings.

2.4 NOTIFICATION APPLIANCE DEVICES

A. Device Color:

1. Wall Mounted: Red housing with white lettering or pictogram.

2. Ceiling Mounted: Red housing with white lettering or pictogram.

3. WG subscript indicates wire guard is required.

B. Visual Alarm Devices:

1. **[FA-200]:** Wall mounted.

2. **[FA-201]:** Ceiling mounted.

3. High intensity (candela rating as scheduled on the drawings) xenon strobe or equivalent under a lens. Candela rating shall be visible from exterior of the device.

   a. Candela Ratings: V1=15, V3=30, V7=75, VH=110, VS=177.

4. The maximum pulse duration shall be 0.2 seconds with a maximum duty cycle of 40%. The flash rate shall be 1 Hz. Where more than two strobes are visible from any one location, the fire alarm visual devices shall be synchronized.

5. Device, housing, and backbox shall be UL listed for fire alarm/emergency applications.

C. Audio (Horn) Low Frequency 520 Hz Alarm Devices for Sleeping Rooms:

1. **[FA-213]**: Wall mounted.

2. **[FA-214]**: Ceiling mounted.

3. Sound rating: 75 dB at 10 feet.

4. Device shall be capable of a high and low dB setting. Unless noted otherwise, the device shall be set to the high setting at building completion.

5. Device, housing, and backbox shall be UL listed for fire alarm/emergency applications.

D. Audio (Horn) Alarm Devices:

1. **[FA-210]**: Wall mounted.

2. **[FA-230]**: Ceiling mounted.

3. Sound rating: 85 dB at 10 feet. Sound levels for alarm signals shall not exceed 120 dBA in the occupied area.

4. Device shall be capable of a high and low dB setting. Unless noted otherwise, the device shall be set to the high setting at building completion.

5. Device, housing, and backbox shall be UL listed for fire alarm/emergency applications.

E. Combination Audio (Horn) and Visual Notification Device:

1. **[FA-211]**: Wall mounted.

2. **[FA-231]**: Ceiling mounted.

3. Combine horn and visual components into a single device. Refer to the corresponding paragraphs above for requirements of each component.

F. **[FA-203]:** Weatherproof Visual Notification Device:

1. High intensity strobe, square housing, 75 candela rating, suitable for wet locations. Provide with weatherproof back box.

2. Mounting: Semi-flush wall.

3. Conduit shall not be exposed.

G. **[FA-233]:** Mini-Horn Audio Notification Device:

1. Electronic horn.

2. Mounting: single-gang flush wall.

H. **[FA-212]:** Weatherproof Audio/Visual Notification Device:

1. Electronic horn with high intensity strobe, square housing, 75 candela, suitable for wet locations. Provide with weatherproof back box.

2. Mounting: Semi-flush wall.

3. Conduit shall not be exposed.

2.5 DOOR HOLD-OPEN DEVICES

A. **[FA-270]:** Electromagnetic Door Holder Devices:

1. Flush wall mounted Surface wall mounted Floor mounted.

2. Voltage: 120V 24VAC 24VDC.

3. Holding force shall be 25 pounds minimum.

4. Provide fail-safe operation; power failure releases door.

5. Provide self-adjusting swivel catch plate with pivot points to adjust to door alignment changes.

6. Provide all hardware and wiring needed to accommodate the complete functioning door holder installation.

7. Ensure that the door hardware and trim projections are compatible with total projection of door release.

8. Provide firm anchoring for the electromagnet, such that the mounting box and device will not move independently from the wall or floor they are mounted to. This device and mounting will function as a doorstop and hold the force of the door closer mechanism.

9. Follow manufacturer's recommended installation and location instructions unless noted otherwise.

10. Electromagnetic door holder devices, housing, and back box shall be UL listed.

2.6 [NEP-#]: NAC EXTENDER PANELS (NEP)

A. As shown on the plans or as a Contractor's option if not shown, furnish and install NAC extender panels as necessary to provide remote power supply for notification appliance circuits (NAC). Contractor shall indicate quantity and locations of each NEP on the shop drawing submittals.

B. Each NEP shall be self-contained remote power supply with batteries, and battery charger mounted in a surface lockable cabinet. Battery capacity shall be sufficient for operation for 24 hours in a non-alarm state followed by alarm for 15 minutes, plus 25% spare capacity for future devices. Each NEP provides a minimum of up to 4 outputs, 2A continuous, or 6A full load total capacity.

C. Power for each NEP shall be from a local 120 VAC emergency circuit. Provide two #12 conductors and one #12 ground in 1/2" conduit to each NEP from a dedicated 20A/1P circuit breaker with a red handle and a manufacturer's standard handle lock-on device. Coordinate panel and circuit number with Architect/Engineer prior to installation.

D. NAC extender panels may be installed only in locations coordinated with the Architect/Engineer.

E. Mounting: Surface.

2.7 ANNUNCIATION

A. **[FAA-#]:** Remote LCD Annunciators:

1. Auxiliary annunciators shall indicate alarm and trouble conditions visually and audibly as shown on the drawings. Provide local TROUBLE ACKNOWLEDGE, TEST, and ALARM SILENCE capability. Minimum 80-character display.

2. Communications and power to the annunciators shall be supervised. The annunciator shall receive power from the fire alarm control panel.

3. A single key switch shall enable all switches on the annunciator.

4. Mounting: Flush.

B. Facility Management Control System (FMCS) Interface:

1. Provide addressable relays to report the following to the FMCS via dry contact monitoring on the FMCS:

   a. General Alarm
   b. System Trouble
   c. Supervisory Alarm
   d. Other Alarms (if applicable)

C. **[FA-241]**: Fire Alarm Remote Indicator:

1. Red LED type.
2. Mounts flush to a single gang box.

D. **[FA-242]**: Fire Alarm Remote Indicator and Test Switch:

1. Red LED type.
2. Key switch test selector.
3. Mounts flush to a single gang box.

2.8 CONNECTIONS TO AUXILIARY DEVICES PROVIDED BY OTHERS

A. **[FA-250]**: Smoke Damper:

1. Motorized type, furnished and installed by MC. Fire alarm control and power connections by EC. A subscript is used to identify the device with a specific air handler or zone for its sequence of operation. Refer to the Operation Matrix and these specifications for complete requirements.

B. **[FA-254]:** Duct Smoke Detector and Smoke Damper Control:

1. Sampling type duct detector [FA-122] in ducts 18" and larger. In-duct smoke detector [FA-123] in ducts less than 18". Detector shall be mounted within 5' of smoke damper. Motorized type smoke damper furnished and installed by MC. Fire alarm control and power connections by EC. Remote indicator [FA-241] or [FA-242] mounted in visible location. Provide auxiliary relay base or addressable control module. The smoke damper shall close upon activation of the detector, and a supervisory signal shall be sent to the fire alarm control panel.

C. **[FA-260]**: Flow Switch:

1. Connection to flow switch to monitor fire protection flow switch or discharge output contacts. Normally open dry contacts for fire alarm interface. Furnished and installed and MC; wired by EC.

D. **[FA-261]**: Monitor Switch:

1. Connection to monitor switch to monitor fire protection system supervisory switches or output contacts. Normally open dry contacts for fire alarm interface. Furnished and installed by MC; wired by EC.

E. **[FA-262]**: Post Indicator Valve:

1. Connection to post indicator valve for sprinkler system supervisory notification. Normally open dry contacts for fire alarm interface. Furnished and installed by MC; wired by EC. Provide surge protection device as recommended by the fire alarm system manufacturer on line entering/leaving the facility.

F. **[FA-263]**: Electronic Bell:

1. Electronic bell for sprinkler alarm, electro-mechanical type, 120 VAC. Furnished and installed by MC. Fire alarm control and power connections by EC.

G. **[FA-271]**: Door Hold Open Device:

1. Integral with door hardware. Furnished and installed by GC. Fire alarm control and power connections by EC.

H. **[FA-272]**: Hold Open Override:

1. Hold open override connection to GC-provided power door operator. EC shall intercept the hold open switch wiring (unless specific contacts for this purpose are provided on the door) and connect addressable relay to override this switch and allow the door to close. All modifications to the power door operator shall be coordinated with the GC.

2.9 WIRING

A. Fire alarm wiring/cabling shall be furnished and installed by the Contractor in accordance with the manufacturer's recommendations and pursuant to National Fire Codes. Cabling shall be UL listed and labeled as complying with NFPA 70, Article 760 for power-limited fire alarm signal service.

B. Approved manufacturers of fire alarm cable:

1. Comtran Corp.
2. Helix/HiTemp Cables, Inc.
3. Rockbestos-Suprenant Cable Corp.
4. West Penn Wire/CDT.
5. Radix.

2.10 STANDALONE DEVICES

A. Approved Manufacturers:

1. Gentex 9120 Series
2. System Sensor
3. Fenwall
4. Gamewell
5. Kidde

B. **[FA-170]:** Smoke Alarm - Audio:

1. 120 VAC with 9V battery backup (batteries supplied by Contractor), photoelectric type, integral test switch, Form A/Form C contacts, 90 dB piezo solid state horn, low/missing battery alarm, pulsing LED sensing chamber, insect screen, LED condition indicator, UL 217 listed.

C. **[FA-171]:** Smoke Alarm - Audio/Visual:

1. 120 VAC with 9V battery backup (batteries supplied by Contractor), photoelectric type, integral 177 candela strobe, integral test switch, Form A/Form C contacts, 90 dB piezo solid state horn, low/missing battery alarm, pulsing LED sensing chamber, insect screen, LED condition indicator, UL 217 listed.

PART 3 - EXECUTION

3.1 SEQUENCES OF FIRE ALARM OPERATION

A. General:

1. Refer to the Fire Alarm Operation Matrix on the drawings for basic requirements and system operation.

2. All system output programs assigned via control-by-event equations to be activated by the particular point in alarm shall be executed, and the associated system outputs (alarm notification appliances and/or relays) shall be activated.

B. Panel/Annunciator Alarm, Trouble, Supervisory Indication:

1. Appropriate system Alarm, Trouble, or Supervisory LED shall flash at the control panel, transponder, and annunciator locations.

2. A local signal in the control panel shall sound.

3. The LCD display shall indicate all information associated with the condition, including the name of the item, type of device and its location within the protected premises.

4. History storage equipment shall log the information associated with the fire alarm control panel (FAP) condition, along with the time and date.

5. Transmit the appropriate signal (supervisory, trouble, alarm) to the central station via the digital communicator.

6. Transmit the appropriate signal (supervisory, trouble, alarm) to the building automation system via addressable relays tied to contact monitors on the system.

C. Audible Alarms Sequence:

1. Audible alarms throughout the building shall sound.

D. Visual Alarms Sequence:

1. Visual alarms throughout the building shall flash.

E. Fire Protection Electric Sprinkler Bell Sequence:

1. The fire alarm shall utilize an addressable relay to energize the electric sprinkler bell upon activation of the flow switch.

F. Double Interlocked Preaction Sprinkler Activation Sequence:

1. The fire alarm system shall utilize an addressable relay to signal the double-interlock preaction sprinkler system to allow filling with water upon initiation of alarm in zone of sprinkler coverage.

2. Where there are multiple zones to the preaction system, a separate addressable relay shall be provided for each zone and the system shall be programmed to signal only the zone that is in the area of the fire. Coordinate with the fire protection system installer.

3. The fire alarm system shall utilize addressable monitor modules to monitor the control panel supervisory and trouble conditions.

G. Clean Agent Release Sequence:

1. The fire alarm system shall utilize an addressable relay to signal the clean agent release panel to activate upon initiation of alarm in two zones of detection.

2. Where there are multiple clean agent zones, a separate addressable relay shall be provided for each zone, and the system shall be programmed to signal only the zone that covers the area of the fire. Coordinate with the clean agent system installer.

H. Kitchen Hood Fire Suppression System Sequence:

1. The fire alarm system shall utilize an addressable relay to de-energize the hood supply fan controller.

2. The fire alarm system shall utilize an addressable monitor module to monitor the fire suppression system.

I. Smoke Damper Control Sequence:

1. The fire alarm system shall utilize an addressable relay to open the power connection to smoke or fire/smoke dampers and allow them to close. Coordinate other requirements with damper installer.

2. Where a damper is located in a main air duct, where closure of that single damper will entirely block airflow in the duct system, the smoke damper sequence shall also initiate the AHU shutdown sequence for the affected unit.

3. The AHU shutdown sequence shall be initiated only when ALL of the dampers associated with that unit are closed. Otherwise, the AHU shall continue to serve other areas.

4. Smoke and fire/smoke dampers located in branch ductwork shall be closed individually or in groups, as identified on the plans.

J. AHU Shutdown Sequence:

1. The fire alarm system shall utilize addressable relays to de-energize all AHU motor controllers. Coordinate other requirements with HVAC installer.

2. The fire alarm system shall directly shut down the AHU through the local HVAC control device (i.e., variable frequency drive or motor starter).

3. Where a facility has more than one AHU, each shall be shutdown individually based on input from initiation devices in the area served by the unit or designated for each AHU.

K. Fire Door Release Sequence:

1. The fire alarm system shall utilize an addressable relay to signal the fire door or curtain to close. Once the alarm is cleared, the addressable relay shall allow the door to open.

2. Where a facility has more than one fire door, each shall release individually based on input from initiation devices in the vicinity of each door and noted specifically for door closure.

L. Door Holder Release Sequence:

1. The fire alarm system shall utilize an addressable relay to open the power connection to integral and magnetic door holders.

2. The fire alarm system shall utilize an addressable relay to open the 'hold' switch circuitry, integral to the power door.

3. Door holders shall release individually based on initiation devices in the vicinity of the door and noted specifically for door closure.

M. Sound Masking Paging System Shutdown Sequence:

1. The fire alarm system shall utilize addressable relays or RS-485 interface to disconnect the signal source or de-energize the amplifiers to shut down all sound masking paging systems. Coordinate with masking paging system supplier to provide necessary interface at all sound system equipment locations.

2. The fire alarm interface and associated relays, etc. shall not induce any noise onto the audio system and shall not affect the performance or audio-quality of the system during normal use.

3.2 INSTALLATION

A. Install system in accordance with manufacturer's instructions and referenced codes.

B. Fire Alarm Control Panel:

1. Install the control panel where shown on the drawings.

2. All expansion compartments, if required, shall be located at the control panel.

3. The fire alarm voice prerecorded messages shall be verified by the Contractor, as approved by the Owner, prior to the shop drawing submittal process.

C. Devices:

1. General:

a. All ceiling-mounted devices shall be located where shown on the reflected ceiling and floor plans. If not shown on the reflected ceiling or reflected floor drawings, the devices shall be installed in the relative locations shown on the floor drawings in a neat and uniform pattern.

b. All devices shall be coordinated with luminaires, diffusers, sprinkler heads, piping and other obstructions to maintain a neat and operable installation. Mounting locations and spacing shall not exceed the requirements of NFPA 72.

c. Where the devices are to be installed in a grid type ceiling system, the detectors shall be centered in the ceiling tile.

d. The location of all fire alarm devices shall be coordinated with other devices mounted in the proximity. Where a conflict arises with other items or with architectural elements that will not allow the device to be mounted at the location or height shown, the Contractor shall notify the Architect/Engineer to coordinate a different acceptable location.

2. Per the requirements of NFPA, detector heads shall not be installed until after the final construction cleaning unless required by the local Authority Having Jurisdiction (AHJ). If detector heads must be installed prior to final cleaning (for partial occupancy, to monitor finished areas or as otherwise required by the AHJ), they shall not be installed until after the fire alarm panel is installed, with wires terminated, ready for operation. Any detector head installed prior to the final construction cleaning shall be removed and cleaned prior to closeout.

3. Analog Smoke and Heat Detectors:

a. In elevator shafts and elevator equipment rooms, provide a heat detector for elevator shutdown within 2' of every sprinkler head. Coordinate with fire protection contractor.

4. Duct-type Analog Smoke Detectors:

a. Duct-type analog smoke detectors shall be installed on the duct where shown on the drawings and details. The sampling tubes shall be installed in the respective duct at the approximate location where shown on the electrical drawings to meet the operation requirements of the system.

b. All detectors shall be accessible.

c. Duct-type detectors shall be installed according to the manufacturer’s instructions.

5. In-Duct Analog Smoke Detectors:

   a. In-duct analog smoke detectors shall be installed in the duct where shown on the drawings and details. The devices shall be installed in the respective duct at the approximate location where shown on the electrical drawings to meet the operation requirements of the system.

   b. All detectors shall be accessible.

6. Manual Pull Stations:

   a. Stations shall be located where shown and at the height noted on the drawings.

7. Addressable Relays and Monitor Modules:

   a. Modules shall be located as near to the respective monitor or control devices as possible, unless otherwise indicated on the drawings.

   b. All modules shall be mounted in or on a junction box in an accessible location.

   c. Where not visible from a floor standing position, a remote indicator shall be installed to allow inspection of the device status from a local floor standing location.

8. Notification Appliance Devices:

   a. Devices shall be located where shown on the drawings.

   b. Wall-mounted audio, visual and audio/visual alarm devices shall be mounted as denoted on the drawings.

   c. Where ceiling mounted visual alarm devices or combination audio/visual alarm devices are shown where the ceiling is greater than 30'-0" high, they shall be stem mounted so that the entire unit is below 30'-0". This does not apply to audio-only alarm devices.

D. Annunciators:

1. Remote Annunciators: The annunciators shall be located where shown on the drawings and approved by the fire marshal.

E. Wiring:

1. Fire alarm wiring/cabling shall be provided by the Contractor in accordance with the manufacturer's recommendations and pursuant to National Fire Codes.

2. Wiring shall be installed in red-colored conduit.

3. All junction boxes shall be painted red with SLC and NAC circuits identified on cover.

4. Fire Alarm Power Branch Circuits: Building wiring as specified in Section 26 05 13.

5. Notification Appliance Circuits shall provide the features listed below. These requirements may require separate circuits for visual and audible devices.

   a. Fire alarm temporal audible notification for all audio appliances.

   b. Synchronization of all visual devices where two or more devices are visible from the same location.

c. Ability to silence audible alarm while maintaining visual device operation.

6. Notification Appliance Circuits shall not span floors or smoke compartments.

7. Signal line circuits connecting devices shall not span floors or two-hour smoke compartments.

8. No wiring other than that directly associated with fire alarm detection, alarm or auxiliary fire protection functions shall be in fire alarm conduits. Wiring splices shall be avoided to the extent possible, and if needed, they shall be made only in junction boxes, and enclosed by plastic wire nut type connectors. Transposing or changing color coding of wires shall not be permitted. All conductors in conduit containing more than one wire shall be labeled on each end, in all junction boxes, and at each device with "E-Z Markers" or equivalent. Conductors in cabinets shall be carefully formed and harnessed so that each drops off directly opposite to its terminal. Cabinet terminals shall be numbered and coded, and no unterminated conductors are permitted in cabinets or control panels. All controls, function switches, etc. shall be clearly labeled on all equipment panels.

F. Fire Alarm Cabling Color Code: Provide circuit conductors with insulation color coding as follows, or using colored tape at each conductor termination and in each junction box.

1. Power branch circuit conductors: In accordance with Section 26 05 53.
2. Signaling line circuit: Overall red jacket with black and red conductors.
3. DC power supply circuit: Overall red jacket with violet and brown conductors.
4. Notification appliance circuit: Overall red jacket with blue and white conductors.
5. Door release circuit: Gray conductors.
6. Central station trip circuit: Orange conductors.
7. Central station fire alarm loop: Black and white conductors.

G. Devices surface mounted in finished areas shall be mounted on surface backboxes furnished by fire alarm equipment supplier. Backboxes shall be painted to match device, shall be the same shape and size as the device shall not have visible knockouts.

H. Make conduit and wiring connections to door release devices, sprinkler flow and pressure switches, sprinkler valve monitor switches, fire suppression system control panels, duct analog smoke detectors and all other system devices shown or noted on the Contract Documents or required in the manufacturer's product data and shop drawings.

3.3 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Section 26 05 00.

B. Test in accordance with NFPA 72, Chapter 14 and local fire department requirements. Submit documentation with O & M manuals in accordance with Section 14.6 of the Code.

C. Contractor shall test and adjust the fire alarm system as follows:

1. Speaker taps shall be adjusted to the lowest tap setting which achieves a sound level higher than or equal to the greatest of the following:

a. 70dBA.

b. 15 dBA above ambient levels as indicated in NFPA 72 Table A.18.4.3.

c. 15 dBA above measured ambient. 5 dBA above the maximum measured sound level with duration of more than 60 seconds.

d. As specified on the drawings.

2. Sound level measurement procedure shall meet the following requirements:

a. All measurements shall use the 'A' weighted, dBA, sound measurement scale.

b. All measurements shall be taken after furnishings, wall coverings and floor coverings are in place.

c. All measurements shall be taken after fixed equipment (HVAC units, etc.) producing ambient noise is installed and is in operation.

d. All sound level measurements shall be taken at a height of 5' above the finished floor level.

e. Measurements shall be taken in every unique room. If there are multiple rooms, which have the identical dimensions and function, 10%, or a minimum of 2 rooms shall be tested. The results from the rooms tested shall be averaged and the remaining rooms may be adjusted per the average.

f. Measurements shall be taken on a 20' x 20' grid and the results for all points taken shall be averaged. If the room is smaller than 20' x 20' a minimum of two measurements are required.

g. Measurements shall be taken halfway between speakers or halfway between a speaker and the wall. No measurements shall be taken at the extreme edges of the room, nor directly under speakers.

D. Additionally, test the voice alarm communication system intelligibility per IEC 60849:

1. The following acoustically distinguishable spaces shall be tested: All unique rooms shall be tested. If there are multiple rooms with the identical dimensions and function, 10%, or a minimum of two (2) rooms, shall be tested. The results from the rooms tested shall be averaged, and the remaining rooms may be adjusted per the average.

2. Utilize equipment designed to test per IEC 60849 per the equipment manufacturer's instructions. This equipment includes a signal generator, which is input to the fire alarm system and a portable measurement device. This equipment is available from Simplex Grinnell or Gold Line.

3. Testing equipment that can simulate 'crowd babble' shall be used in rooms with occupancy of greater than 200.

4. Wide-area notification intelligibility shall be tested in acoustically distinguishable spaces and areas as designated by the Owner.

5. When testing for intelligibility, the quantity and location of the measurement points shall be the same as the points used for measurement of dBA level.

6. Provide a room by room report, showing the average dBA level and STI for each room tested, the number and location of. The report shall be presented to the Architect/Engineer in an Excel .xls file.

3.4 MANUFACTURER'S FIELD SERVICES

A. Provide manufacturer's field services under provisions of Section 26 05 00.

B. Include services of certified technician to supervise installation, adjustments, final connections, and system testing.

C. Note that room numbers depicted on the architectural/engineering drawings will not necessarily reflect the actual room (signage) numbers that the Owner selects. The Contractor and fire alarm manufacturer shall coordinate the actual room numbers as the Owner directs to identify each device. This list shall be a part of the floor plan record drawing to be turned in at the project closeout.

END OF SECTION

SECTION 31 05 00
COMMON WORK RESULTS FOR EARTHWORK OUTSIDE BUILDING FOOTPRINT

PART 1 - GENERAL

1.1 SCOPE

A. Work Included: Furnish all labor, equipment, and materials to complete all earthwork including:

1. Site clearing, grubbing, stripping, and earth moving.
2. Excavation, filling, backfilling, compaction, and grading.
3. Preparation of subgrade for slabs on grade, walks, pavements, roads, and parking areas.
4. Proof-rolling of Subgrade.
5. Furnish, apply, and rough grade topsoil.
6. Removal of structures at or below grade.
7. Provide and pay for all necessary permits.
8. Shoring, cribbing, and bracing to safely support excavations.
9. Contractor shall determine if the site "balances" and include in their bid any import or export of material including any spoils from utilities.

B. Work Not Included: Excavating and backfilling inside and outside of building as required for plumbing, heating, and electric work installed underground, including tanks, pits, manholes, catch basins and inlets, which are included in other Sections.

1.2 REFERENCE STANDARDS

A. ASTM A444 - Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process for Culverts and Underdrains

B. ASTM C136 - Sieve Analysis of Fine and Coarse Aggregates

C. ASTM C207 - Hydrated Lime for Masonry Purposes

D. ASTM D1556 - Standard Test Method for Density of Soil in Place by the Sand - Cone Method

E. ASTM D422 - Particle Size Analysis of Soils

F. ASTM D423 - Liquid Limit of Soils

G. ASTM D424 - Plastic Limit and Plasticity Index of Soils

H. ASTM D698 - Moisture-Density Relations of Soils and Soil-Aggregate. Mixtures using 5.5 lb. Rammer and 12 inch Drop (Standard Proctor Test)

I. ASTM D1452 - Soil Investigation and Sampling by Auger Borings

J. ASTM D1557 - Moisture Density Relations of Soils and Soil - Aggregate Mixtures using a 10 lb. Rammer and 18 inch Drop (Modified Proctor Test)

K. ASTM D2167 - Density of Soil in Place by the Rubber-Balloon Method

L. ASTM D2487 – Classification of Soils for Engineering Purposes

M. ASTM D2922 - Standard Test Methods for Density of Soil and Soil-Aggregates in Place by Nuclear Methods (Shallow Depth).

N. Standard Specification for Highway and Structure Construction, State of Wisconsin.

O. Specification 01 45 29 Laboratory Testing

1.3 QUALITY ASSURANCE

A. Perform earthwork in compliance with local, state, and OSHA requirements.

B. Project Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of the geotechnical engineer and represent interpretations of the subsoil conditions, tests, and results of analyses conducted by the geotechnical engineer. Owner will not be responsible for interpretations or conclusions drawn from this data by Contractor.

1. Contractor shall make additional test borings and conduct other exploratory operations as necessary.

2. The geotechnical report is included in the Existing Conditions section of the Project Manual.

C. Testing and Inspection Service: Owner shall engage soil testing and inspection service (Geotechnical Engineer) for quality control testing during earthwork operations.

1. Additional copies of testing reports shall be sent to the architect.

2. Testing agency representatives on the site are required to read and understand the requirements of the Construction Documents, the Soil Report, and this Section. Contractor shall verify this condition.

3. Proofrolling, undercutting, and fill operations shall be performed under the observation of the Geotechnical Engineer.

4. Approval by Geotechnical Engineer must be given prior to the placing of any concrete or fill material, and whenever the Soil Report or actual conditions encountered indicate loose or variable soil conditions, variable soil coloration, unexpected materials, etc. Do not proceed if unsuitable conditions are encountered. Notify Geotechnical Engineer immediately.

5. Testing agency shall provide to Owner, Architect, and Engineer written field reports that topsoil and unacceptable soils have been removed, reports of actual bearing pressures encountered, and all compaction tests. Provide written verification that existing soils and fill materials achieve specified bearing capacity at all locations including lawn and unpaved areas.

6. Provide Geotextile Fabric Information to Geotechnical Engineer for review.

D. Grading Limits: Confine work to the Construction Limits as indicated on the drawings. In the absence of such a designation on the drawings, confine work to the minimum area reasonably necessary to undertake the work as determined by the Engineer. All areas disturbed by excavation and grading, plus such additional areas as are disturbed by construction related activities including construction access and storage and installation of materials shall be considered the "Construction Area."

E. Wherever provisions of the Specification, Drawings, including supplements and addenda, or the requirements of Geotechnical Engineer conflict (e.g. compaction materials, required percent compaction, etc.), the more stringent requirements shall govern unless approved in writing by Engineer.

F. Conform to Federal, State, and local ordinances with respect to excavations, disposal of waste, burning, air quality, noise, erosion, water runoff, etc.

G. Record Drawings: Maintain record drawings of all underground utilities, drain tiles, or other structures encountered, and/or earthwork made as part of this project on original drawings prepared by the installing Contractor/Subcontractor.

H. Earth Retention System: Contractor is completely responsible for the design and construction of adequate and safe temporary shoring, bracing, retaining structures, and excavations. All systems shall be designed for potential sand seams and water, which may cause cave-ins, and/or require additional bracing, casing of bore holes, dewatering, etc.

1.4 SUBMITTALS

A. None

1.5 QUANTITIES

A. Elevations provided on the plans are finished elevations including topsoil. Finish topsoil depth shall be as specified in this section or as shown on the drawings, whichever is greater.

B. Contractor shall be solely responsible for determining all earthwork quantities based on the existing and proposed elevations provided on the plans. Any geotechnical investigations provided by the Owner apply only to those locations that the data was collected, and may not be indicative of conditions elsewhere on the site. The Contractor is responsible for collecting any additional geotechnical or survey data he deems necessary to complete an accurate estimate of earthwork quantities.

C. Contractor shall be solely responsible for balancing site materials. If onsite excavation and borrow operations do not provide enough suitable material for fill areas, Contractor shall coordinate and pay for excavation, transport, and placement of imported material meeting the specifications of the contract documents. If excavation results in excess materials, Contractor shall coordinate and remove all excess materials from the site (at no cost to the owner). No excess material can remain onsite.

D. If contractor finds the geotechnical information or existing or proposed elevations shown on the plans to be erroneous, he shall notify the Project Manager immediately.

PART 2 - PRODUCTS

2.1 FILL MATERIALS

A. Structural Fill: Well graded, granular material, bankrun sand and gravel, or crushed or natural stone, free of shale, clay, friable materials, and debris; tested in accordance with ANSI/ASTM C136 within the following limits:

1. Maximum size of aggregate shall be 2" with not more than 80% passing on a 3/4 inch sieve, with not less than 50% by weight passing a No. 4 sieve.

2. Not more than 15% shall pass the No. 200 sieve.

3. When used for bedding under pipes, conduits or culverts, fill shall consist of material with greater than 50% by weight passing a No. 4 sieve and all particles passing a l inch sieve. Bedding material shall be selected and placed in accordance with the recommendations of the pipe manufacturers and in accordance with Chapter 6.43 of Standard Specifications for Sewer and Water Construction in Wisconsin, Latest Edition.

    a. Fill above utilities shall be clay where existing soils are clay.

b. For all utilities and other excavations, provide anti-seep, concrete collars or cut-off walls, or other suitable means to cut off water where a water source could flow back to building.

4. Structural Fill shall achieve the required soil bearing pressure specified in the Contract Documents and Soil Report.

B. Fill placed in fabric or geogrid reinforced sub-grade areas in pavement areas shall be granular soil, such as 1-1/4 inch or 3/4 inch crushed stone aggregate, or other as recommended by the geotechnical engineer. Aggregate should not exceed the maximum recommended by the geotextile manufacturer.

C. Drainage Fill: Frost resistant, well graded, clean, angular/fractured, crushed stone or gravel (not sand), free of silt, clay, loam, friable or soluble materials, and organic matter; tested in accordance with ANSI/ASTM C136 within the following limits:

1. Not more than 5% shall pass the No. 200 sieve.

a. Slab on grade subgrade: ASTM C33, Size 67.

b. Building perimeter drain lines shall be surrounded with at least 12 inches of washed aggregate conforming to ASTM C33, Size 67.

c. Perimeter drains at retaining walls shall be surrounded with at least 12 inches of washed aggregate conforming to ASTM C33, Size 67.

D. No. 2 Stone: Angular crushed limestone aggregate having uniform particle size of nominally 2 inches, essentially free of fines.

E. Lean Concrete: Minimum 1,500 psi compressive strength at 28 days.

F. Common Fill: Approved material from site, excavation or offsite, separated from materials which do not compact by tamping or rolling. Crushed stone, bank run gravel, or coarse sand or general earth material free of particles larger than 6 inches, debris, peat, roots, cinders, wood, trash, organic material or other objectionable material.

G. No organic, deleterious or frozen or "contaminated" material may be used for backfilling or fill material.

H. Geotextile Material: Conforming to WISDOT 645 and Soil Report with respect to Grab, Puncture and Burst Strength, Trapezoidal Tear, Permativity, and Apparent Opening Size.

1. Around stone surrounding draintile and trench drains: WISDOT 645.2.4 Type DF, Type A or better:

2. "Mirafi 140-N"

3. "ADS 5000"

4. "Amoco 4547"

5. "Contech C-45NW"

6. Approved equal

7. Under slab-on-grade when specified on plans as required: WISDOT 645.2.2 Type SAS:

8. "Mirafi 180-N"

9. "Mirafi FW404"

10. "ADS 8800"

11. "Amoco 4553"

12. "Contech C-80NW"

13. Terra Tex-N08"

14. Approved equal

15. Soil stabilization and subgrade reinforcement above poor soils: WISDOT 645.2.3 Type MS:

16. "Tensar BX-1200"

17. Approved equal

2.2 TOPSOIL

A. Topsoil to be furnished: If quantity of stored topsoil is inadequate or if none has been salvaged from site, this Contractor shall furnish sufficient topsoil to properly construct lawns. Topsoil furnished shall be a natural, fertile, friable soil, possessing characteristics of representative productive soils in the vicinity. It shall be obtained from naturally, well-drained areas. It shall not be excessively acid or alkaline or contain toxic substances which may be harmful to plant growth. Topsoil shall be without admixtures of stones, stumps, roots, debris or other objects 1" or more in diameter which might be a hindrance to planting operations. Topsoil shall be placed to a minimum depth of 6" after compaction.

B. Landscape Contractor shall provide, spread, and fine grade topsoil.

PART 3 - EXECUTION

3.1 GENERAL

A. Contractor to review specific method of soil preparation as listed in the geotechnical report.

B. Contractor to establish all heights and grades to properly execute work from benchmark established by a surveyor (from original survey work). It is strongly recommended that the original surveyor be contacted and used for all construction layouts as well as as-built surveys in an effort to avoid conflict between datums and horizontal control points used. Prior to construction layout, existing and proposed finished floor elevations shall be checked with respect to current site benchmarks to ensure elevations correspond with layout elevations.

C. Contractor shall provide all construction layout surveys to accurately locate the construction on the site.

D. Prior to start of work, Contractor shall be completely familiar with all conditions at the site, and shall account for conditions that may affect the work including: Geotechnical recommendations and methods, limitations on work access, space limitations, overhead obstructions, traffic patterns, local requirements, adjacent activities, etc. Failure to consider these requirements shall not be cause for claim of job extras.

E. Inspect areas and conditions prior to clearing, excavating, filling, and grading. Do not proceed until unsatisfactory conditions have been corrected.

F. Permits and Fees:

1. Apply for, pay for, and secure all permits required in connection with the work under this section from the governmental authorities having jurisdiction.

2. Pay all highway and dumping fees and repair damage to sidewalks, streets, or other public property, or to any public utilities.

3.2 PROTECTION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout and other hazards created by earthwork and dewatering operations. Protect and maintain all lawns, beds, shrubs, trees, and other work that is to remain in place. See Specification 01 76 00 Protecting Installed Construction for additional information.

1. Should damage occur as a result of work performed under this Contract, restore to existing condition at no additional cost to Owner, in a manner acceptable to Architect.

2. Repair or replace trees and vegetation indicated to remain which are damaged by construction operations, in manner acceptable to Architect.

B. Conduct site clearing operations to ensure minimum interference with roads, streets, walks, and other adjacent occupied or used facilities. Do not close or obstruct roads or other occupied or used facilities without permission from Owner and authorities having jurisdiction.

C. Carefully remove items indicated to be salvaged, and store on Owner's premises where indicated or directed.

D. Provide and maintain temporary fences, planking, lights, warning signs, barricades, and guards necessary for protection of premises and public.

E. Maintain cut at satisfactory slope which will prevent collapse of embankments. Provide bracing and shoring as required to protect existing improvements, including outside contract limits, new construction or excavations. Contractor is solely responsible for strength and adequacy of bracing or shoring and for safety. Conform to OSHA requirements. Restore any damaged improvements to their original condition.

F. Do not load vehicles hauling debris excessively as to cause spillage on to streets and roadways. Do not allow spilled materials to clog drainage of streets.

G. Keep sidewalks and streets adjoining the property broom clean and free of debris, excavated materials, rubbish, trash and obstructions, which might affect the safety of streets, walks, utilities and property. Broom clean daily.

H. Use all means necessary to control dust on and near the work, if such dust is caused by the Contractor's operations during performance of the work, or if resulting from the condition in which the Contractor leaves the site.

I. Provide positive protection (mat/sheet coverings) for all excavation slopes to protect slopes from instability and deterioration due to rain, wind or snow/ice.

J. Construct, maintain and protect erosion and sedimentation controls.

3.3 EXISTING UTILITIES

A. The Contract Drawings show such information as can reasonably be obtained regarding the location and nature of pipe lines, storm sewers, water lines, natural gas lines, underground cables, etc. However, the accuracy or completeness of such information is not guaranteed. It shall be Contractor's responsibility to locate such underground features sufficiently in advance of operations to preclude damage to same.

B. Locate existing underground utilities in the areas of work. If utilities are to remain in place, provide adequate means of support and protection during earthwork operations.

C. Should uncharted or incorrectly charted, piping or other utilities be encountered during excavation, consult Architect and appropriate utility company immediately for directions. Cooperate with Owner and utility companies for keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility company. The cost of repair of uncharted or incorrectly charted utilities will not be paid by the Owner.

D. Do not interrupt existing utilities serving facilities occupied and used by Owner or others except when permitted in writing by Architect and then only after acceptable temporary utility services have been provided. Provide minimum of 48-hour notice to Owner, and receive written notice to proceed before interrupting any utility.

E. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies for shut-off of service if lines are active.

3.4 SITE CLEARING AND GRUBBING

A. Clear area within contract limits of trees, stumps, brush, shrubs, vegetation, rubbish, and other perishable or objectionable matter.

B. Remove all cleared material from site.

C. An effort has been made to show the majority of existing trees on-site on the plans, however, Contractor to visually verify removal limits prior to bidding.

D. Existing bituminous and concrete paving, roads, walks, and curbs shown in areas of proposed improvements or reused grades, shall be removed by this Contractor to a depth of at least 10” below the paved surface.

E. Completely remove stumps, roots, and other debris protruding through ground surface. Use only hand methods for grubbing inside drip line of trees indicated to remain.

F. Remove existing above-grade and below-grade improvements, unsuitable fill, cinders, concrete, old foundations and any other unsuitable material as indicated on Drawings, soil report or interfering with new construction.

G. Burying or burning of materials on the site is not permitted.

H. Trim limbs and branches of trees to be left in place which overhang roadbeds or structure to provide proper clearance.

3.5 SITE GRADING

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

B. Preparation of subgrades after stripping vegetation, organic or other unsuitable materials shall consist of:

1. Proof-rolling under the observation of an experienced Geotechnical Engineer or Technician to detect soft, wet, yielding soils or other unstable materials. Proof rolling shall consist of rolling the subgrade with a heavily loaded rubber tired vehicle such as a loaded scraper or tandem axle dump truck.

a. Undercut soft or unsuitable areas of subgrade 2 to 3 feet or as directed by Geotechnical Engineer. Backfill with granular soil (as indicated in the geotechnical report) fill in maximum 8 inch loose lifts, and compact to the minimum required degree of compaction as specified in Compaction Section.

b. Remove the top 18" of the subgrade where expansive clays (Liquid Limit greater than 50) are encountered. Replace with granular structural fill.

c. Remove, as directed by Geotechnical Engineer, underlying bearing soils that are disturbed by construction, weather or earthwork activities, and replace with structural, engineered fill.

d. In pavement areas, backfill half of undercut with No. 2 stone placed in 8" lifts and compacted until no further vertical and lateral movement is observed. Backfill upper half of undercut with Base Coarse Aggregate placed in 8" lifts and compacted as specified in Compaction Section.

e. Provide Geotextile Fabric before backfilling, if soft soils exist at bottom of excavation.

2. Scarify top 6 to 8 inches.

3. Moisture condition soils as required.

4. Recompaction to same minimum in-situ density required for similar materials.

5. Stone Base course shall be proof-rolled prior to placing pavement section as well.

C. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect, without additional compensation.

D. All subgrades shall consist of and be:

1. Underlain by suitable bearing material.

2. Free of all organic, frozen or other deleterious material.

3. Observed, tested and approved by Geotechnical Engineer.

3.6 CUT AND FILL

A. Provide all necessary cutting and filling required to change existing grade specified or as shown on drawings.

1. Note: A vibratory smooth drum roller should not be used on clay soils.

2. In areas under proposed pavement, consult with geotechnical engineer and report for construction methods.

3. Rough grade all seeded areas to 6" below finish grade elevation. Where topsoil of sufficient depth is encountered, grade shall be brought to final established grade. Minimum depth of topsoil shall be 6".

4. All roads, drives, and parking areas etc. shall be rough graded to 15" below finish grade, or as required to install subgrade and finish pavement.

B. Fill in excess of 12" shall be constructed in 8" layers and shall be rolled with rubber tired equipment or sheepsfoot rollers, or compacted with vibratory equipment, whichever is best suited for soil being compacted. Fill under paved areas shall be compacted to 95 percent Modified Proctor, as per ASTM D 1557.

C. Where there is a great change in grade, a maximum slope of three to one (3:1) shall be maintained. Reference Section 31 25 00 - Erosion Control for Specific Requirements.

D. Do no grading until sewers, water mains and other utilities are installed. After backfill has settled and when directed, fill shallow places to bring to proper grade.

E. Excess excavated material from trenches and other excavations will be piled on site if to be reused, or removed from site by respective Contractors. Deposition and spreading shall be done by this Contractor.

1. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

2. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.7 EXCAVATING

A. Excavate and remove whatever materials encountered, including existing pavements, abandoned building foundation walls, footings and slabs, and unsuitable fill as required to place within finish elevations shown, all footings, walls, trenches, pits, ground floor slabs, drain tiles inside and around basement to complete the project.

1. Remove rock to lines and grades indicated, to permit installation of permanent construction without exceeding the following dimensions: 12 inches outside of concrete forms at footings.

2. 6 inches outside of minimum required dimensions of concrete cast against grade.

3. 6 inches beneath bottom of concrete slabs on grade.

B. Maintain pit or pits to which all excavated parts shall be drained. Provide, operate and maintain suction and discharge lines, pumps and other equipment necessary to drain and keep all excavations, trenches and entire subgrade area free of water under any and all circumstances which may arise. Notify Geotechnical Engineer if springs or water seepage are encountered during grading for possible construction procedure revisions or inclusion of subgrade drainage system.

C. Excavated earth shall remain on site, if possible, and placed where directed.

1. After final grading work is complete, remove any excess earth from premises. Where site constraints dictate, excavated earth shall be stored off-site or landfilled.

2. All surplus earth shall be removed from premises.

D. Additional Excavation: When excavation has reached required subgrade elevation, notify Architect and Geotechnical Engineer for inspection of conditions.

E. Unauthorized Excavation: Consists of removal of materials beyond indicated subgrade elevations, limits or dimension without specific direction of Geotechnical Engineer. Unauthorized excavation, as well as remedial work directed by Architect and/or Geotechnical Engineer, shall be at Contractor's expense.

F. Frost Protection: All open footings, trenches and exposed floor slab areas must be protected against frost impregnation.

G. Stability of Excavations:

1. Slope sides or excavations to comply with governing codes and ordinances, including OSHA Subpart P of 29 CFR 1926, or successor regulations. Shore and brace where sloping is not possible because of space restrictions or stability of material excavated. Unless required otherwise by code or unless authorized by Geotechnical Engineer, slopes for excavations 20 feet deep or less should not exceed 1:1 for soil Types A and B and 1-1/2 (horizontal):1 (vertical) for soil, Type C.

2. Maintain side and slopes of excavations in a safe condition until completion of backfilling.

H. Do not place excavated materials where they will inconvenience the public, impede travel, or impede surface drainage unless such drainage is being safely rerouted away from the excavation without causing

other damage. Do not place excavated materials close to a trench or excavation, unless shoring of adequate strength is provided to support the additional loads that are imposed.

I. Tunnel under, or remove and replace, sidewalk and curb in areas of excavation to the nearest joint. Remove all pavements, including curbs and gutters, to neat and straight lines to the limits of removal by a two-step method. Limit the initial removal to the immediate area of the proposed work. Full depth sawcutting is not required for this phase of the removal. After the work is completed, and immediately prior to the pavement replacement, make a full depth sawcut to neat and straight lines outside the widest point of excavation. Make the lines of sawcut parallel to existing joints, or parallel or perpendicular to pavement edges so as to form a neat patch. Carefully remove all remaining pavement within the sawcut area to the lines of the sawcut. Do not disturb existing base materials between the area disturbed by the work and the sawcut line during the sawcutting, pavement removal, or pavement replacement processes.

J. If field tile are encountered during the excavation, the Contractor shall make provisions for continuing the drainage on an interim basis and immediately notify the Architect and Geotechnical Engineer. Field tiles shall be re-routed wherever possible.

3.8 GEOTEXTILE FABRIC

A. Install in accordance with WISDOT 645, Soil Report and Manufacturer's Specification and Requirements with a minimum overlap of two (2) feet.

1. Provide around drain tile, wherever shown on drawings and/or recommended/specified in the Soil Report.

2. Where piping vertically intersects the Geotextile Fabric, run fabric up pipe and tape prior to backfilling.

3. Where horizontal piping is installed after and below the Geotextile,

a. Cut the Geotextile in a line centered on the pipe excavation and fold back.

b. After pipe installation, backfill to the bottom of the Geotextile, fold the fabric back, and tape the joint.

c. Tape a 4 foot wide strip of Geotextile, centered over the cut joint.

B. Geotechnical Engineer shall review and approve installation and provide written report to Architect/Engineer.

3.9 BACKFILL AND FILL

A. General: Place acceptable tested and approved soil material in layers to required subgrade elevations, for each area classification listed below.

1. Structural/Engineered Fill:

a. Use as fill or backfill in excavations against walls (except as noted in Item 2), under walks, steps and pavements and under interior building slabs, except as noted in Item 3 below.

b. Use as bearing material below footings and above natural occurring bearing soil where unsuitable material has been removed.

c. Amount or width of structural fill against walls shall be per this specification, as shown on drawings, or as directed by Geotechnical Engineer. The more stringent requirement shall be used.

2. Drainage Fill:

   a. Use as final 6" minimum layer (or greater as shown on Contract Documents or Soil Report) for granular sub-beds under all exterior floor slabs resting on earth and exterior sidewalks, and steps.

   b. Use around all drain tile, piping, etc. prior to backfilling with structural fill.

3. Exterior Pavement Subbeds: Use as final 6" minimum layer (or greater as specified on the plans, in Section 32 11 23.33 Dense Graded Base or Soil Report) for granular crushed stone sub-bed under exterior drives, parking areas and ramps. See Soil Report for pavement design requirements.

4. Common Fill: Use under unpaved exterior areas.

B. Prior to Backfill Placement: Backfill excavations as promptly as work permits but not until completion of the following:

1. Acceptance by Geotechnical Engineer of construction below finish grade.

2. Inspection, testing and approval of underground utilities and systems.

3. Removal of shoring and bracing, and backfilling of voids with satisfactory materials. Cut off temporary sheet piling driven below bottom of structures and remove in manner to prevent settlement of the structure or utilities, or leave in place if required.

4. Surveying locations of underground utilities for Record Documents.

5. Removal of mud, water, caved-in, softened or disturbed soil, or frozen soil as directed by Geotechnical Engineer.

6. Removal of trash and debris.

7. When existing ground surface has a density less than that specified under "Compaction" for the particular area classification, break up the ground surface, pulverize, moisture-condition to the optimum moisture content, and compact to required percentage of maximum density.

C. Placement and Compaction:

1. Place backfill and fill materials in layers not more than 8" in loose depth for material compacted by heavy compaction equipment, and not more than 4" in loose depth for material compacted by hand-operated tampers. Equipment shall be compatible with type of soil to be compacted.

2. Place backfill and fill materials evenly adjacent to structures, to required elevations. Take care to prevent wedging action of backfill against structures by carrying the material uniformly around structure to approximately same elevation in each lift. Lifts should be placed horizontally and in uniform thicknesses.

3. Extend fill a lateral distance of at least 1 foot for each foot of new fill required, with a minimum of six feet (6') beyond the edge of buildings and foundations. Against walls, free-draining granular structural backfill should extend a lateral distance of at least 4 feet from the outside face of the wall.

4. Notify, coordinate and cooperate with Testing Agency regarding placement of fill. Each layer must be approved before the next layer is started.

3.10 COMPACTION

A. General: Control soil compaction during construction, providing minimum percentage of density specified for each area classification.

B. It is the responsibility of the Contractor to provide all necessary compaction equipment and other grading equipment that may be required to obtain the specified compaction. Compaction of controlled backfill by travel of grading equipment will not be considered adequate for uniform compaction. Hand guided vibratory or tamping compactors will be required whenever controlled backfill may be placed adjacent to walls, footings, columns or in confined areas.

C. Percentage of Maximum Density Requirements:

1. Compact soil to not less than the following percentages of maximum dry density determined in accordance with ASTM D1557, Modified Proctor Test. For clay soils, use ASTM D698 Standard Proctor methods and add 3% to percentages specified below, not to exceed 100%.

2. Foundations Fill: For fills less than or equal to 8 feet thick, compact the top 12" of existing soils and each layer of backfill or fill material to 95% maximum dry density. For fills greater than 8 feet thick, compact to 100% maximum dry density.

3. Lawn or Unpaved Areas: Compact the top 6" of existing soils and each layer of backfill or fill material to 88% maximum dry density, except future expansion areas shall be 95% maximum dry density.

4. Sidewalks: Compact the top 6" of existing soils and each layer of backfill or fill material to 95% maximum dry density.

5. Pavements: Compact the top 12" of existing soils and each layer of backfill or fill material to 95% maximum dry density, or until additional passes over the crushed stone produce visually no additional compaction.

6. Utility trench backfill should be compacted to at least 90% of the Modified Proctor (ASTM D1557) maximum dry density from 1 foot above the top of the pipe or conduit up to final surface grade to minimize subsidence. Under structures and pavements, compaction should be at least 95%. Trench backfill should be placed in lifts of 12 inches or less. Placement shall conform to Standard Specifications for Sewer and Water Construction in Wisconsin.

D. Moisture Control:

1. Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water to surface of subgrade, or layer of soil material. Scarify or disk as required to distribute water uniformly through soil. Apply water in manner to prevent free water appearing on surface during or subsequent to compaction operations. The moisture content of the soil should be within -1.0% to +2.5% for cohesive soils, -3% to +3% for cohesionless soils, of the optimum moisture content as determined by ANSI/ASTM D1557.

2. Remove and replace, or scarify by repeatedly plowing and discing during favorable weather conditions to air dry, soil material that is too wet to permit compaction to specified density.

3. Soil material that has been removed because it is too wet to permit compaction may be stockpiled or spread and allowed to dry. Assist drying by discing, harrowing or pulverizing until moisture content is reduced to a satisfactory value.

4. Clay soil bearing capacity and compaction levels are highly affected by water and construction activities.

a. Clay soils may require continued moisture control, modification with Portland Cement or hydrated lime, and/or per Maintenance Section of this specification until drainage subgrade and slab on grade are installed.

3.11 FINAL GRADING

A. General: Uniformly grade area within limits of grading under this section, including adjacent transition areas. Smooth finished surface, compact with uniform levels or slopes between points where elevations are shown, or between such points and existing grades. If fill is to be placed and compacted at the edge of a slope steeper than 4H:1V, overfill a minimum of 2 feet laterally beyond the final grade and trim back to design slope after achieving required degree of compaction.

B. Grading Outside Building Lines: Grade areas adjacent to building lines to drain away from structures and to prevent ponding. Finish surfaces free from irregular surface changes.

1. All contours and/or spot elevations shown on Drawings are to finish grade, unless otherwise noted (i.e. top of pavement, topsoil, etc.). Contractor shall be responsible for making excavations or embankments to the subgrade elevations necessary such that the addition of the pavement, topsoil or whatever surface improvement, will ensure that finished grades are met.

2. Contours indicated on drawings are the finished grade elevations. Review all grade elevations before commencing work to insure that proper slopes for drainage, slopes for drives, walks, paving, etc., are maintained. If Contractor believes a deficiency is apparent, he shall notify the Architect for clarification and correction.

3. Pavements:

a. Shape the surface of the areas under pavement to line, grade and cross-section, compacted as specified, and graded to prevent ponding of water after rains. Rough grade tolerance shall conform to +0 in./-1 1/2 in. Fine grading tolerance shall conform to +0 in./-3/4 in.

b. Include such operations as plowing, discing, and any moisture or aerating required to provide the optimum moisture content for compaction.

c. Fill low areas resulting from removal of unsatisfactory soil material, obstructions, and other deleterious materials, using structural fill material. Shape to line, grade, and crosssection as shown.

4. Ditches: Finish ditches to ensure proper flow and drainage. Conduct final rolling operations to produce a hard, uniform and smooth cross-section.

C. Grading Surface of Fill Under Slabs: Grade smooth and even, free of voids, compacted as specified, and to required elevation. Provide final grades within a tolerance of +0 in./-3/4 in.

D. Compaction: After grading, compact subgrade surfaces to the percentage of maximum density for each area classification.

E. Preparation for Lawn Construction: Preparation of Subgrade: Grade and uniformly compact subgrade so that it will be parallel to proposed finished grade. Loosen subgrade materials and mix to a depth of 8". Remove all stones over 1" in size and remove all sticks and rubbish. Do not move heavy objects, except lawn rollers, over lawn areas after the subgrade soil has been prepared unless subgrade soil is again graded and loosened, as specified above, before topsoil is spread.

3.12 GRAVEL SUB-BEDS

A. Grade Control: During construction, maintain lines and grades including crown and cross-slope of subbase course. Grade and compact earth to required level to receive full depth of pavement including sub-beds.

B. Shoulders: Place shoulders along edges of subbase course to prevent lateral movement. Construct shoulders of acceptable soil materials, placed in such quantity to compact to thickness of each subbase course layer. Compact and roll at least 12 in. (0.3 m) width of shoulder simultaneously with compacting and rolling of each layer of subbase course.

C. Placing:

1. Stone base course shall only be installed after successful proof-roll (immediately preceding), observed by geotechnical engineer.

2. Place subbase course material on prepared subgrade in layers of uniform thickness not to exceed 8", conforming to indicated cross-section and thickness.

3. Maintain optimum moisture content (within -1% to +3%) for compacting subbase material during placement operations.

4. Wet down gravel sub-beds before pouring concrete (if applicable).

5. Placing tolerance: +0 in./-3/4 in.

D. If tests indicate work does not meet specified requirements, recompact or remove work, replace and retest at no cost to Owner.

3.13 MAINTENANCE

A. Protection of Graded Areas:

1. Protect newly graded areas from traffic and erosion. Keep free of trash and debris.

2. Repair and re-establish grades in settled, eroded, and rutted areas to specified tolerances.

B. Reconditioning Compacted Areas: Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, re-shape and compact to required density prior to further construction.

C. Settling: Where settling is measurable or observable at excavated areas during general project warranty period, remove surface (pavement, lawn or other finish), add backfill material, compact, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.14 DISPOSAL OF EXCESS AND WASTE MATERIALS

A. Removal from Owner's Property: Remove excess and waste materials, including excavated material, excess topsoil, trash and debris, and dispose of it off Owner's property.

3.15 UNANTICIPATED SUBSURFACE CONDITIONS

A. If Contractor encounters conditions that are different during earthwork, paving and foundation construction operations than those anticipated, this fact shall immediately (within 24 hours) be brought to Owner's attention. If Owner's representative on the construction site observes subsurface conditions which are different than those anticipated by the Soil Report, this fact shall immediately (within 24 hours) be brought to Contractor's attention. Once unanticipated conditions have been identified, and Consultant has concurred, immediate negotiations will be undertaken between Owner and Contractor to arrive at a change in contract price for additional work or reduction in work because of the unanticipated conditions. Contractor agrees that unit prices as stated in the Bid Form shall apply for additional or reduced work under the Contract.

1 **END OF SECTION**

SECTION 31 22 16.15
ROADWAY SUBGRADE PREPARATION

PART 1 - GENERAL

1.1 SCOPE

A. The work under this section shall consist of providing all work, materials, labor, equipment, and supervision necessary to complete pavement subgrade preparation and provide a surface ready for constructing and supporting the Dense Graded Base, as required in these specifications, on the drawings and as otherwise deemed necessary to complete the work.

1.2 RELATED WORK

A. Applicable provisions of Division 1 govern work under this Section.

B. Related work specified elsewhere:

1. Section 30 05 00 – Common Work Results For All Exterior Improvements
2. Section 31 25 00 – Erosion Control
3. Section 32 11 23.33 – Dense Graded Base
4. Section 01 45 29 - Laboratory Testing

1.3 REFERENCE STANDARDS

A. Where these specifications do not cover portions of the work to be undertaken, the SSHSC in Wisconsin, current edition, shall govern the work.

1.4 QUALITY ASSURANCE

A. The Contractor shall conduct sampling, testing, and analysis as required by this section and elsewhere in the Contract Documents either by retaining the services of an independent construction materials testing consultant or with internal certified testers. The materials testing consultant shall meet the requirements of ASTM E329.

B. The A/E and Contractor's construction materials testing personnel shall observe all proof-rolling operations. The Owner's Project Representative shall also be informed of all proof-rolling operations. Provide minimum of 48 hours notice for all parties.

1.5 PERMITS/FEES

A. Contractor shall be solely responsible for obtaining all permits necessary to complete the work. Contractor shall pay all fees associated with obtaining permits. These include, but are not limited to permits for work within public right-of-way, land disturbance permits and building permits.

PART 2 - MATERIALS

2.1 BREAKER RUN AGGREGATE

A. Crushed stone, rock or gravel meeting the requirements of either Breaker Run or Select Crushed material as defined in WisDOT Section 311.2 or WisDOT Section 312.2, respectively.

2.2 RECYCLED AGGREGATE AND PAVEMENT

A. Recycled or salvaged aggregate and pavement products shall be free of organics, clay, rocks greater than 3-inches in least dimension and all other deleterious materials. The successful Bidder may submit specifications for these materials for consideration by the A/E for use on the project as part of the submittal process following contract award.

2.3 GEOTEXTILE FABRIC

A. Fabric shall be insect, rodent, mildew, and rot resistant woven or nonwoven polyester, polypropylene, stabilized nylon, polyethylene, or polyvinylidene chloride. All fabric shall have the minimum strength values in the weakest primary direction. Fabric shall conform to WisDOT Section 645.2.8.

PART 3 - EXECUTION

3.1 PREPARATION

A. Review drawings and prepare work plan and schedule. Coordinate any necessary interruptions in site access with Owner's Project Representative, in accordance with other specification sections.

B. Remove topsoil from work area. Sawcut and remove pavement from work area as indicated on the drawings. Sawcuts shall be made for the full depth of pavement.

C. Grade roadways and parking areas to drain water away from buildings.

3.2 EXCAVATION

A. Excavate to elevations and dimensions as shown on the drawings and as necessary to complete construction. Excavations shall be sufficiently deep to provide for depth of base course and pavement.

B. Stones over 6-inches in size shall be removed from the loosened portion of the subgrade.

C. Notify OWNER'S Project Representative if correction of unauthorized excavation or over-excavation is necessary. Said excavations will be corrected by placement of Breaker Run Aggregate. Contractor will be responsible for all costs associated with correcting these excavations.

D. Segregate the various materials excavated. Excavated material that does not meet the requirements of backfill and excess excavated material, shall be removed from the site and disposed by the Contractor, unless directed otherwise by other specification sections or the Owner's Project Representative.

E. Locate spoil piles so they do not interfere with public travel, adjacent landowners or other construction activities.

3.3 PREPARING THE FOUNDATION

A. The subgrade shall be constructed to have a uniform stability throughout. Use of recycled and salvaged aggregate and pavements shall be fully incorporated into subgrade soil. Construct the foundation to the required elevation with equipment and methods adapted for the purpose. Shape and compact to provide a smooth foundation, at required density, and at the proper elevation to receive the Dense Grade Base (See Section 32 11 23.33).

B. Compact material to minimize settlement and avoid damage to structures, pipes, utility lines and other features. Hand-place and compact material as necessary.

C. It is the responsibility of the Contractor to provide all necessary compaction equipment and other grading equipment that may be required to obtain a subgrade that satisfies the conditions of a satisfactory subgrade as defined below. Vibratory plate or tamping type walk behind compactors will be required whenever backfill is placed adjacent to structures, pipes, utility lines and other features.

D. The prepared foundation shall be tested for compaction as defined in the paragraph entitled 'Subgrade Approval / Proof Rolling'.

3.4 SUBGRADE APPROVAL / PROOF ROLLING

A. Prior to undercutting or excavating below subgrade (EBS) or placing any Dense Grade Base (See Section 32 11 23.33), contact the Owner's Project Representative to schedule inspection of the subgrade and proof rolling of the subgrade. All proof rolling shall be completed in accordance with the requirements of the paragraph entitled 'Quality Assurance' and shall meet the criteria as defined below.

B. To complete proof rolling, entire pavement subgrade shall be provided with a relatively smooth surface, suitable for observing soil reaction during proof rolling.

C. Contractor shall schedule and provide a fully loaded tri-axle dump truck for proof – rolling. Loaded truck shall have a minimum gross operating weight of 30 tons. Test shall be conducted with "tag" or "pusher" axles retracted from the ground.

D. Proof rolling shall be accomplished in a series of traverses parallel to the centerline of the driveway, street, or parking area. The truck shall traverse the length of the street or parking area once for each 12' of width at speeds less than 5 mph. Additional passes along the traverse shall be completed as directed by the Owner's Project Representative to further define unsatisfactory subgrade.

E. Soft areas, yielding areas, cracked areas or areas where rolling or wave action is observed shall be considered indicative of an unsatisfactory subgrade. Such areas shall be undercut as outlined in subsequent subsections of this specification.

F. Once the subgrade has been proof-rolled and approved, protect the soils from becoming saturated, frozen, or adversely altered.

3.5 UNDERCUTTING/EXCAVATION BELOW SUBGRADE (EBS)

A. Undercutting/EBS shall be completed only when directed by the OWNER'S Project Representative or if unsatisfactory subgrade, as defined above, is observed. The Contractor shall not be compensated for any unauthorized undercutting/EBS. Measure and document undercut areas and depths in consultation with OWNER'S Project Representative.

B. Excavate undercut areas to the depth specified by A/E or Owner's Project Representative using equipment with smooth cutting edge. Excavated undercut material that does not meet the specifications for fill needed elsewhere on site shall be removed from the site and legally disposed.

C. Undercut areas shall be backfilled with Breaker Run (or with a combination of Breaker Run and Geotextile Fabric) in maximum of 9 inch thick lifts (compacted). Breaker Run shall be compacted to 90% Modified Proctor dry density.

D. Following installation and compaction of place Breaker Run material, the area shall be subject to the work defined in the paragraph entitled 'Subgrade Approval / Proof – Rolling'.

E. Undercutting/Excavation Below Subgrade (EBS) work shall include all materials, labor, equipment and supervision necessary to remove the soils from the Project Site considered to be poor from the proof roll and backfill and compact with Breaker Run material brought to the Project Site. The cost of the compacted Breaker Run material is incidental to the unit price item for Undercutting/Excavation Below Subgrade (EBS). If Geotextile Fabric is required and is used in combination with the Breaker Run, the unit price for the Geotextile Fabric shall include all materials, labor and equipment for installation.

3.6 RESTORATION

A. Roll all pavement subgrade surfaces using a smooth drum roller to promote an impervious surface and minimize percolation of water into the subgrade.

1 **END OF SECTION**

SECTION 31 23 00
FOUNDATION EXCAVATING AND BACKFILLING

PART 1 - GENERAL

1.1 DESCRIPTION

A. The General and Supplementary Conditions of the Construction Contract and Division 1 - General Requirements apply to the work specified in this section.

B. This section shall include, but is not limited to the following foundation, excavating and backfilling within five feet of the building perimeter.

1. Removal of all unacceptable soil.
2. Furnish and install acceptable fill as specified herein and on the drawings.
3. Prepare subgrade for footings and slab on grade.

C. The following items are not a part of this specification:

1. Utility trenching and related backfilling outside the building footprint.
2. Subgrade for exterior walks and paving.

D. Structural notes indicated on the drawings regarding foundation excavating and backfilling should be considered part of this specification.

1.2 QUALITY ASSURANCE

A. Codes and Standards: Comply with the provisions of the following codes, specifications and standards, except where more stringent requirements are shown or specified.

1. ASTM C136 – Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
2. ASTM D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbs/ft^3)
3. ASTM D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using the Modified Effort. (56,000 ft-lbs/ft^3)
4. ASTM D2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).
5. ASTM D2940 - Standard Specification for Graded Aggregate Material for Bases and Sub-bases for Highways or Airports.
6. ASTM D4253 - Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
7. ASTM D4254 - Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
8. ASTM D6938 – Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

B. Comply with all applicable local, state and federal codes.

1.3 SUBMITTALS

A. Material Test Reports: Provide the Owner and Architect with the on-site material test reports from the Inspection Agency indicating the interpreting test results for compliance with this specification.

B. LEED Certification: Submit manufacturer's certification for each engineered fill material including the following:

1. LEED Credit MRc 4.1/4.2 – Recycled content including percentage of pre-consumer (post-industrial) and post-consumer recycled content. Also provide manufacturer's name and product cost.

2. LEED Credit MRc 5.1/5.2 – Location of manufacturing plant, manufacturer's name, product cost and location of extraction or harvest of raw materials.

1.4 TESTING AND INSPECTION

A. Inspection and Testing:

1. The Contractor shall employ an Inspection Agency to perform the duties and responsibilities specified below.

2. Refer to architectural, civil, mechanical, and electrical specifications for testing and inspection requirements of non-structural components.

3. Duties of the Inspection Agency:

a. Perform all testing and inspection required per the Testing and Inspection Schedule indicated below.

b. Furnish inspection reports to the building official, the Owner, the Architect, the Engineer of Record, and the General Contractor. The reports shall be completed and furnished within 48 hours of inspected work.

c. Submit a final signed report stating whether the work requiring Inspection was, to the best of the Inspection Agency's knowledge in conformance with the approved plans and specifications.

4. Structural Component Testing and Inspection Schedule for Section 31 23 00 is as follows:

Foundation Preparation	Continuous	Periodic
Verify materials below shallow footings are adequate to achieve the design bearing capacity.		X
Verify excavations are extended to proper depth and have reached proper material.		X
Perform classification and testing of compacted fill materials.		X
Verify use of proper materials, densities, and lift thicknesses during placement and compaction of compacted fill.	X	
Prior to placement of compacted fill, observe subgrade and verify that the site has been properly prepared.		X

B. Minimum testing frequency and locations:

1. Laboratory Testing:

a. Granular fill: One representative gradation test for each type of material.

b. Cohesive soils: One representative moisture density test for each type of material used.

c. Non-cohesive soils: One representative moisture density test for each type of material used.

2. Field Testing:

a. The Inspector shall determine the location of testing.

b. Testing of final utility trench backfill shall begin at a depth of 2 feet above the top of the pipe.

c. In-place field density test and moisture content tests shall be performed as follows:

1) Fills not within the influence of building foundations and slab on grade: Per civil specifications.

2) Fills within the influence of building foundations and slab on grade, the following criteria shall apply: One test for each 8 inch vertical lift of compacted fill placed per 2,500 square feet of fill area (minimum of two tests per lift per structure for areas smaller than 5,000 square feet).

d. Additional testing may be required by the Inspector if noncompliance or a change in conditions occurs.

e. If a test fails, the Contractor shall rework the material, recompact and retest as necessary until specific compaction is achieved in all areas of the trench. All costs associated with this work, including retesting, shall be the responsibility of the Contractor.

1.5 PROTECTION

A. Contractor shall provide for design, permits and installation of all cribbing, bracing, shoring and other methods required to safely retain earth banks and excavations.

B. Notify the Architect immediately and discontinue work in affected area if adjacent existing footings are encountered during excavation. Underpin other adjacent structures that may be damaged by excavation work, including service utilities and pipe chases.

C. Notify the Architect of unexpected subsurface conditions and discontinue work in affected areas until notification to resume.

D. Protect benchmarks, existing structures, fences, sidewalks, paving, curbing, etc., from excavation equipment and vehicular traffic.

E. Maintain and protect above and below grade utilities that are to remain.

F. Provide temporary heating or protective insulating materials to protect subgrades and foundations soils against freezing temperatures or frost during cold weather conditions.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Provide borrow soil materials when sufficient acceptable soil materials are not available from excavations.

B. Acceptable soils shall comply with the following:

1. Meet ASTM D2487 soil classification groups GW, GP, GM, SW, SP, SM or a combination of these group symbols;

2. Be free of rock or gravel larger than 3 inches in any dimension;

3. Be free of debris, waste, frozen materials, vegetation and other deleterious materials;

4. Have a liquid limit less than 45 and a plasticity index less than 20.

5. Be approved by the Inspection Agency.

C. Unacceptable soils shall be defined as following:

1. ASTM D2487 soil classification groups GC, SC, ML, MH, CL, CH, OL, OH, PT or a combination of these group symbols.

2. Unacceptable soils also to include acceptable soils not maintained within 2 percent of optimum moisture content at time of compaction.

D. Free-Draining Granular Fill: Free-draining granular fill shall comply with the following:

1. Be a naturally or artificially graded mixture of natural or crushed gravel, crushed stone.

2. Be clean and free of fines.

3. Comply with ASTM D2940.

4. Be uniformly graded as follows:

COARSE AGGREGATE GRADATIONS						
SIEVE SIZE - PERCENT PASSING						
Grade No.	1-1/2"	1"	3/4"	1/2"	3/8"	No. 4
CA7	100	95 ± 5	-	45 ± 15	-	5 max

5. Be approved by the Inspection Agency.

E. Engineered Fill and Utility Base Course shall comply with the following:

1. Be a naturally or artificially graded mixture of natural or crushed gravel, crushed stone, natural or crushed sand; be a recycled concrete crushed to meet the gradation requirements of CA6;

2. Comply with ASTM D2940;

3. Be uniformly graded as follows:

COARSE AGGREGATE GRADATIONS						
SIEVE SIZE - PERCENT PASSING						
Grade No.	1-1/2"	1"	1/2”	No. 4	No. 16	No. 200
CA6	100 to 90	95 ± 5	75 ± 15	43 ± 13	25 ± 15	8 ± 4

4. Be approved by the Inspection Agency.

F. Material Applications: Provide and install material meeting with the above requirements as follows:

1. General fill: Acceptable soils.

2. Backfill at over-excavated areas beneath footings: Engineered fill.

3. Sub-grade layer beneath slabs-on-grade: Refer to Drawings.

2.2 LEED CREDIT

A. LEED Credit MRc 4.1/4.2 – All engineered fill shall contain 100% recycled content.

B. LEED Credit MRc 5.1/5.2 – All fill materials shall be procured from within 500 miles of the project site.

PART 3 - EXECUTION

3.1 PREPARATION

A. Identify and verify required lines, levels, contours and benchmark elevations for the work are as indicated.

B. Protect plant life, lawns, other features and vegetation to remain as a portion of the final landscaping.

C. Groundwater is expected during excavation. Contractor shall provide for de-watering of excavations from surface water, ground water or seepage.

D. Identify known underground utility locations with stakes and flags.

3.2 EXCAVATION

A. All excavations shall be safely and properly backfilled.

B. All abandoned footings, utilities and other structures that interfere with new construction shall be removed.

C. All unacceptable material and organic material shall be removed from below all proposed slabs-on-grade and the exposed natural soil shall be proof rolled and the compaction verified by the soils testing firm prior to placing fill. Proof-roll with a loaded tandem dump truck, loaded ready-mix truck, roller, or equivalent weight vehicle. Materials exhibiting weakness, such as those exhibiting rutting or pumping, shall be removed and replaced with acceptable compacted fill material.

D. Do not excavate within the 45-degree bearing splay of any adjacent foundations.

E. Remove lumped subsoil, boulders and rock up to 1/3 cubic yard (measured by volume). Provide Owner with unit price per cubic yard for obstructions larger than 1/3 cubic yard.

F. Outside 45-degree bearing splay of foundations, correct areas over excavated with aggregate at no additional cost to the Owner.

G. Within the 45-degree bearing splay of foundations, correct areas over excavated with 2000 psi concrete fill at no additional cost to the Owner. Notify the Architect prior to performing such work.

H. Hand trim final excavation to remove all loose material.

I. Contractor shall form all dams and perform other work necessary for keeping the excavation clear of water during the progress of the work and, at his own expense, shall pump or otherwise remove all surface and perched water which accumulates in the excavations. Perched water that cannot be de-watered in 48 hours of continuous pumping at a minimum rate of 60 gpm in dry weather shall be considered ground water.

J. Stockpile excavated material in the area designated and remove excess material not being used, from the site.

3.3 BACKFILLING

A. Support pipe and conduit during placement and compaction of bedding fill.

B. Systematically backfill to allow necessary time for natural settlement. Do not backfill over porous, wet, spongy or frozen subgrade surfaces.

C. Backfill areas to contours and elevations with unfrozen materials.

D. Unless noted otherwise on the Drawings, make grade changes gradual.

E. Unless noted otherwise on the Drawings, slope grade away from the building a minimum of 2 inches in 10 feet.

F. Contractor shall procure the approval of the subgrade from the Inspection Agency prior to the start of any filling or bedding operations.

G. Do not begin any backfill operations against any concrete walls until the concrete has achieved its specified strength.

H. Place and mechanically compact granular fill in continuous layers not to exceed loose lifts of 10-inch depth.

I. Employ a placement method that does not disturb or damage adjacent utilities, vapor barriers, foundation perimeter drainage and foundation waterproofing.

J. All surplus fill materials are to be removed from the site.

K. Fill material stockpiles shall be free of unacceptable soil materials.

L. After work is complete, remove all excess stockpile material and repair stockpile area to its original condition.

3.4 COMPACTION

A. Compact all fill that will support building footings or floor slabs to 95 percent of the maximum dry density in accordance with ASTM D1557. For relative cohesionless fill materials, where the percent passing the #200 sieve is less than 10 and the moisture density curve indicates only slight sensitivity to changing moisture content, compaction requirements should be changed to 75 percent relative density in accordance with ASTM D4253 and ASTM D4254.

B. Compact all fills that support paving and landscape per civil specifications.

3.5 FOUNDATIONS

A. Each footing excavation should be cleared of all obstructions and other organic or deleterious materials.

B. Localized areas of unstable or unacceptable material may be discovered during the stripping and excavation operation and may require over-excavation and backfilling. The Inspection Agency shall be present during the proof rolling to evaluate any localized areas and make recommendations regarding over-excavation, backfilling and recompaction of these areas. Fill placement and compaction shall be inspected and tested by the Inspection Agency.

C. Footing elevations shown on the Drawings designate a minimum depth of footing where a safe soil bearing pressure is expected. Footings, piers and/or walls shall be lowered or extended as required to reach soil meeting the design bearing pressure. This work shall be performed under direct supervision of the Inspection Agency.

D. All footing excavations shall be recompacted by hand-operated, vibratory compaction equipment.

E. All excavation and recompacted surfaces shall be inspected and tested to a depth of 2.0 feet below the excavated elevation by the Inspection Agency. Additional field density tests should be performed for each one foot of fill material placed. Any areas not in compliance with the compaction requirements should be corrected and re-tested prior to placement of fill material.

F. For foundation areas where over excavation is performed, place and mechanically compact Engineered fill material in continuous layers not to exceed loose lifts of 10-inch depth.

3.6 SLAB-ON-GRADE

A. All disturbed areas after the clearing and stripping operation should be proof-rolled and recompacted with a heavy vibratory drum roller (approved by the Inspection Agency) in the static mode. The compactor should make a minimum of 10 passes, with a minimum of one foot overlap of each pass. The compactor speed should be less than 0.2 MPH.

B. The Inspection Agency shall monitor proof-rolling and compaction operations. This area should then be tested for compaction to a depth of 2.0 feet below the compacted surface prior to the placement of any structural fill material.

C. Refer to Drawings for required sub-grade preparation beneath slabs-on-grade.

3.7 UTILITY TRENCH BACKFILL (AT SLAB ON GRADE LOCATIONS)

A. Excavate and backfill utility trenches under wall footings as shown on the Drawings

B. Place utility base course on subgrades free of mud, frost, snow, or ice.

C. Place and compact utility base course on trench bottoms and where indicated.

D. Lay underground utilities on 6” sand bedding, which meets the acceptable criteria of Section 2.1,B.

E. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

F. After connection joints are made, any misalignment can be corrected by tamping the sand around the utilities.

G. Place and compact initial backfill of acceptable sand to a height of 6 inches over the utility pipe or conduit in 6 inches layer meeting specified compaction requirements.

H. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of piping or conduit.

I. Place and compact final backfill using acceptable soil to final subgrade elevation meeting specified compaction requirements.

J. Backfill voids with acceptable soil while installing and removing shoring and bracing.

K. Inspection Agency shall monitor and test compacted backfill to verify final compaction meets the specified requirement.

3.8 TOLERANCES

A. Top surface of backfilling under paved areas: Plus or minus ½ inch from required elevation.

B. Top surface of general backfilling: Plus or minus 1 inch from required elevation.

END OF SECTION

SECTION 31 23 19
DEWATERING

PART 1 - GENERAL

1.1 SCOPE

A. The work under this section shall consist of providing all work, materials, labor, equipment, and supervision necessary to provide for dewatering as required in these specifications, on the drawings and as otherwise deemed necessary to complete the work. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- References
- Submittals
- Quality Assurance
- Permits/Fees Safety
- Erosion and Sedimentation Control
- Environmental Contaminants
- Noise Pollution

PART 2 - MATERIALS
- General

PART 3 - EXECUTION
- General
- Sump Dewatering
- Well Installation
- Operation
- Removal/Abandonment

1.2 RELATED WORK

A. Applicable provisions of the General Conditions and Division 01 govern work under this Section.

Section 31 05 00	Common Work Results for Earthwork (Outside Building Footprint)
Section 31 25 00	Erosion Control

1.3 REFERENCES

A. Wisconsin Department of Safety and Professional Services (SPS):

Chapter NR 141 – Monitoring Well Construction

Chapter NR 812 – Well Construction and Pump Installation

B. Wisconsin Department of Natural Resources Technical Standards for Construction Site Erosion & Sediment Control (Technical Standards)
http://www.dnr.state.wi.us/org/water/wm/nps/stormwater/techstds.htm#Construction

1.4 SUBMITTALS

A. When deep wells or well point systems are utilized, provide system design computations for the removal of groundwater and design information for sediment removal practices.

B. For sump dewatering in trenches of excavations, provide copies of sediment removal practice

selection discharge design calculations of information.

C. When permits are required for dewatering, provide copies of all permits.

D. Provide copies of daily monitoring and testing logs for dewatering practices as described in the DNR Dewatering Technical Standard.

E. Provide copies of all borehole abandonment forms.

1.5 QUALITY ASSURANCE

A. Provide and submit a quality assurance program for maintaining erosion control and sediment control practices. As work progresses through phases of the contract, submit copies of the updated quality assurance program for erosion control and sediment removal processes.

1.6 PERMITS/FEES

A. Pay for and obtain all permits/approval required by local, state and federal regulations.

B. Necessary permits/approval may include, but are not limited to high capacity well approval under NR 812.09 and erosion control permits.

C. When installing by jetting methods, provide own water source. Do not use hydrants as water source without permission from Construction representative and/or local utility, as applicable. Obtain and pay for any required hydrant use and permits.

1.7 SAFETY

A. Prevent public access to hazardous dewatering system components.

B. Abandon boreholes in accordance with applicable local, state and federal codes immediately following use.

1.8 EROSION CONTROL

A. Comply with the requirements of the specification sections listed under related work in part 1 of this section.

B. Selection, installation, operation, and maintenance of erosion control and sediment removal measures related to a dewatering system shall be done in accordance with the DNR Dewatering Technical Standard or equivalent approved by the WDNR.

C. Upon installation of the dewatering system, immediately remove any mud, sediment or drilling fluid generated by jetting or rotary drilling operations.

D. When overland discharge of water is necessary, dissipate energy of water stream using nozzles, deflectors, riprap or other methods.

E. Inspect dewatering system daily for signs of erosion and eliminate cause of erosion.

1.9 ENVIRONMENTALCONTAMINANTS

A. Monitor dewatering system discharge regularly for signs of chemicals or other environmental contaminants.

B. If chemicals or environmental contaminants are observed, terminate dewatering system operation immediately and contact the Construction Representative.

C. Prevent dewatering system from introducing contaminants into the soil or groundwater.

1.10 NOISE POLLUTION

A. Provide mufflers, housing, berms and fencing as necessary to minimize noise pollution resulting from dewatering system operation.

PART 2 - MATERIALS

2.1 GENERAL

A. All deepwell and wellpoint dewatering equipment and well construction/abandonment materials shall meet the requirements of NR 141 and NR 812.

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with all local, state and federal regulations.

B. When deep wells or well point systems are utilized, prepare a system design and obtain permits in accordance with NR 812.09 for high capacity wells as defined by NR 812.07(53). Design system to dewater site as necessary to complete construction, but minimize impact on local water table. Monitor water levels in wells adjacent to construction site. Adjust dewatering system configuration and operation as necessary if neighboring wells are adversely impacted. Do not adversely impact neighboring private wells.

C. Coordinate installation of dewatering system with other contractors. Locate dewatering system components in locations that do not interfere with site operations or other construction activities.

D. Pump groundwater at lowest rate necessary to dewater site as required to accommodate other sitework.

3.2 SUMP DEWATERING

A. Install collection sump in the low point of the excavation(s).

B. Provide filter material, trash screens and other devices around pump or intake to avoid pumping of sediment.

3.3 OPERATION

A. Provide personnel, equipment and power necessary to maintain and operate the dewatering system as required to complete construction at the site.

B. Do not discharge water containing sediment, debris or contaminants into the sanitary sewer system or waters of the state.

3.4 REMOVAL/ABANDONMENT

A. Remove all dewatering system components immediately following use.

B. Clean receiving storm sewer system of any sediment or debris deposits resulting from dewatering system operation.

1 **END OF SECTION**

SECTION 31 25 00
EROSION CONTROL

PART 1 - GENERAL

1.1 SCOPE

A. The work under this section consists of providing all work, materials, labor, equipment, and supervision necessary to provide and construct erosion control measures necessary to protect property and the environment.

1.2 RELATED WORK

A. Applicable provisions of Division 01 govern work under this Section.

B. Section 31 05 00 Common Work Results For Earthwork (Outside Building Footprint)

C. Provide erosion control in accordance with the following references:

1. Wisconsin Department of Natural Resources Technical Standards For Construction Site Erosion and Sediment Control. http://dnr.wi.gov/org/water/wm/nps/stormwater/techstds.htm

2. Erosion Control Product Acceptability List ("PAL"), current version as published by the WisDOT. http://wisconsindot.gov/Documents/doing-bus/eng-consultants/cnslt-rsrces/tools/pal/pal-8-11-2017.pdf

D. Method of measurement and basis of payment sections in any referenced erosion control documents shall not apply to this contract.

E. These documents are available from: State of Wisconsin Document Sales and Distribution 202 South Thornton Avenue; P.O. Box 7840; Madison, WI 53707; 608-266-3358

1.3 PERMITS

A. Contractor shall be responsible for obtaining and maintaining all erosion control permits associated with the project.

1.4 SUBMITTALS

A. The Lead Contractor will submit the following to the A/E:

1. Contractor shall mark-up of the Erosion Control Plan that is included in these documents showing additional or alternate erosion control measures as needed due to the Contractors means and methods throughout all phases of construction. The Contractor may also be required to submit calculations and backup information showing the proposed measures meet applicable regulations.

2. Submittals for materials used to implement the erosion control plan.

B. Submit shop drawings for the following erosion control features:

1. Silt Fence

2. Inlet Sediment Guards

3. Erosion Mat

1.5 EROSION CONTROL PLAN

A. The A/E has prepared an erosion control plan for the project and will apply for the required NOI permit. The Contractor will provide the A/E with submittals for materials used to implement the erosion control plan, as well as any modifications to the erosion control plan that are necessary due to the Contractor's means and methods of construction.

B. Contractor shall comply with all the requirements of the erosion control plan, and the Wisconsin Pollutant Discharge Elimination System, WPDES. The project specific WPDES Construction Site Stormwater Discharge Permit for Erosion Control and the City of Madison Erosion Control Permit shall supersede the General Permit.

C. Erosion control and storm water management practices shall be installed and maintained in accordance with City of Madison and WDNR approved Technical Standards (or equivalent).

D. Contractor shall provide all erosion control practices necessary to protect property and the environment. Erosion control and storm water management practices shall be installed and maintained in accordance with the WDNR approved Technical Standards (or equivalent).

PART 2 - PRODUCTS

2.1 GENERAL

A. Erosion mats, soil stabilizers, and tackifiers shall be listed on the Product Acceptability List for Multi-Modal

B. Applications ("PAL") as published by the Wisconsin Department of Transportation.

C. When the design or contract includes permanent erosion control or stormwater control features, the contractor may employ these items in his control of erosion and stormwater during his construction activities. However, these items shall be fully cleaned, restored, and in every way fully functioning for its intended permanent use prior to acceptance of the work.

2.2 STRAW BALE BARRIERS

A. Rectangular bales of hay or straw, tightly bound with twine, not wire.

B. Anchor stakes shall be "T" or "U" steel posts, or hardwood, 2.0 by 2.0 inches nominal. Rebar shall not be used to anchor bales.

2.3 SILT FENCE

A. Fence fabric shall comply with the requirements of Standard Specifications for Highway Construction 628.2.6, in 3 foot tall rolls, with 4' tall 2" x 2" nominal cross section hardwood posts spaced a maximum of 10' o.c. Silt fence shall be Mirafi, Trevira, Amoco, CFM, or approved equal.

2.4 EROSION MAT

A. A straw/coconut fiber mat encased in an accelerated photodegradable polypropylene top net. Erosion mat shall comply with the requirements of Class I, Type A erosion mat as defined by Standard Specifications for Highway Construction and the PAL. Erosion mat shall be American Excelsior, SI Geosolutions, Erosion Control Systems, North American Green, or approved equal.

B. Concentrated Areas/Channels (as indicated on plans): This mat shall be North American Green SC150, or approved equal.

C. Erosion Mat at Storm Outlets: This mat shall be ProPex LandLok 300, or approved equal.

D. Erosion Mat in bio-filtration and raingarden areas shall be North American Green SC-150BN or approved equal.

2.5 STAPLES

A. Use biodegradable staples in accordance with manufacturer's recommendations for materials being anchored. Wood and metal staples are not allowed.

2.6 RIP-RAP

A. Rip rap shall be the class specified and shall conform to Standard Specifications for Highway Construction Section 606.2.

2.7 TRACKING PAD STONE

A. The aggregate for tracking pads shall be 3 to 6 inch clear or washed stone. All materials shall be retained on a 3-inch sieve.

2.8 SOIL STABILIZERS

A. Soil stabilizers shall be non-asphalt-based products of the type specified, and meeting the requirements of the PAL.

2.9 SOIL TACKIFIERS

A. Soil tackifiers shall be non-asphalt-based products of the type specified, and meeting the requirements of PAL.

2.10 POLYMERS

A. Polymers used to settle suspended sediment shall meet the requirements of the WDNR Technical Standards.

PART 3 - EXECUTION

3.1 GENERAL

A. Install erosion control measures as required by the erosion control plan and contract documents. Provide additional erosion control measures as dictated by Contractor's means and methods, or by differing site conditions. Notify Construction Representative of additional erosion control features that are provided, but not shown on the plan.

B. Contractor shall provide all erosion control measures necessary to protect property and the environment. Include all erosion control measures as required by the most stringent of applicable sections of DNR Technical Standards or the Standard Specifications for Highway Construction.

C. Perform all work in accordance with manufacturer's instruction where these specifications do not specify a higher requirement.

D. Contractor shall comply with all the requirements of the erosion control plan, and if applicable, the WPDES Stormwater Discharge Permit for Erosion Control, including required monitoring and documentation.

3.2 GRADING AND EARTHWORK

A. Install all temporary or permanent erosion control measures prior to any onsite grading or land disturbances.

B. Clear only those areas designated for the placement of improvements or earthwork before placement of the final cover. Perform stripping of vegetation, grading, excavation, or other land disturbing activities in a logical sequence and manner which will minimize erosion. If possible, schedule construction for times of the year when erosion hazards are minimal.

C. Do not clear the site of topsoil, trees, and other natural ground covers before the commencement of construction. Retain natural vegetation and protect until the final ground cover is placed.

D. Temporary stockpiles are to be located greater than 25 feet from any roadway, parking lot, paved area, drainage structure, or channel.

E. Provide temporary stabilization and control measures (seeding, mulching, covering, erosion matting, barrier fencing, etc.) for the protection of disturbed areas and soil piles which will remain uncovered for a period of more than 7 consecutive calendar days.

F. Remove surplus excavation materials from the site immediately after rough grading. The disposal site for the surplus excavation materials shall also be subject to these erosion control requirements.

3.3 DRAINAGE

A. Minimize water runoff and retain or detain on-site whenever possible so as to promote settling of solids and groundwater recharge.

B. Convey drainage to the nearest adequate stormwater facility. Do not discharge water in a manner that will cause erosion or sedimentation of the site or receiving facility.

C. Protect storm sewer inlets and catch basins in accordance with the erosion control plan, if provided, a log with the WDNR Technical Standards and PAL. If not specified, protect inlets with straw bale barriers, silt fencing, filter basket, or other equivalent methods approved by the Engineer which provide the necessary erosion protection.

D. Divert roof drainage and runoff from all areas upslope of the site around areas to be disturbed or channel them through the site in a manner that will not cause erosion.

E. Ditch checks are to be provided in swales or ditches to reduce the velocity of water in the channel. Construct in accordance to DNR Technical Standards and PAL.

F. Minimize the pumping of sediments when dewatering. Discharge to a sedimentation basin/trap or sedimentation vessel to reduce the discharge of sediments. Do not discharge water in a manner that will cause erosion or sedimentation of the site or receiving facility. Refer to section 31 23 19 Dewatering for specifications.

3.4 TRACKING CONTROL

A. Construct and maintain tracking pads in accordance with the Technical Standards. Provide each entrance to the site with a stone tracking pad at least 50 feet in length with a minimum thickness of 12 inches. The tracking pad shall be the full width of the egress point. Inspect tracking pads on a daily basis and replace aggregate when no longer effective.

B. If necessary, provide a crushed aggregate paved parking area.

C. If applicable, wash water shall be discharged to sedimentation basins, sedimentation vessels, or other such control areas.

3.5 MAINTENANCE

A. Inspect all erosion control measures within 24 hours of the end of each rainfall event that exceeds 0.25", or daily during period of prolonged rainfall, or weekly during periods without rainfall. Immediately repair and/or replace any and all damaged, failed, or inadequate erosion control measures.

B. Re-apply soil stabilizers, tackifiers, polymers and anionic polycrylamides as needed to prevent erosion of exposed soil.

C. Maintain records of all inspections and any remedial actions taken.

D. Maintain stockpile stabilization measures as necessary after rainfall events and heavy winds. Replace tarps, re-seed, and reapply mulch, tackifiers and stabilizers as necessary.

E. Remove sediment from stormwater and erosion control structures, basins and vessels as necessary.

F. Repair or replace damaged inlet protection.

G. Replace or supplement stone tracking pads with additional stone when they become ineffective.

H. Remove any sediment reaching a public or private roadway, parking lot, sidewalk, or other paved. Do not remove tracked sediments by flushing. Completely remove any accumulations not requiring immediate attention at least once daily at the end of the workday.

I. Frequently dispose of all waste and unused construction materials in licensed solid waste or wastewater facilities. Do not bury, dump, or discharge, any garbage, debris, cleaning wastes, toxic materials, or hazardous materials on the site, on the land surface or in detention basins, or otherwise allow materials to be carried off the site by runoff onto adjacent lands or into receiving waters or storm sewer systems.

END OF SECTION

SECTION 31 26 00
STEEL HELICAL PILES

PART 1 - GENERAL

1.1 DESCRIPTION:

A. The General and Supplementary Conditions of the Construction Contract and Division 1 - General Requirements apply to the work specified in this section.

B. The work includes all items required for executing and completing the steel helical pile work and related work shown on the drawings or specified herein.

C. Structural notes indicated on the drawings regarding steel helical piles should be considered a part of this specification.

D. No substitutions will be allowed without the Engineer of Record's approval.

1.2 QUALITY ASSURANCE

A. Codes and Standards: Comply with the provisions of the following codes, specifications, and standards except where more stringent requirements are shown or specified herein:

1. ASCE 20 - Standard Guidelines for the Design and Installation of Pile Foundations.

2. ASME B18.2.1 - Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series).

3. ASTM A29 - Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought.

4. ASTM A36 - Standard Specification for Carbon Structural Steel.

5. ASTM A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

6. ASTM A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

7. ASTM A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

8. ASTM A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.

9. ASTM A252 - Standard Specification for Welded and Seamless Steel Pipe Piles.

10. ASTM A320 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.

11. ASTM A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.

12. ASTM A513 - Standard Specification for Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing.

13. ASTM A536 - Standard Specification for Ductile Iron Castings.

14. ASTM A572 - Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.

15. ASTM A618 - Standard Specification for Hot-Formed Welded and Seamless High-Strength Low-Alloy Structural Tubing.

16. ASTM A656 - Standard Specification for Hot-Rolled Structural Steel, High-Strength Low-Alloy Plate with Improved Formability.

17. ASTM A958 - Standard Specification for Steel Castings, Carbon, and Alloy, with Tensile Requirements, Chemical Requirements Similar to Standard Wrought Grades.

18. ASTM A1018 - Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Carbon, Commercial, Drawing, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.

19. ASTM D1143 - Standard Test Methods for Deep Foundations Under Static Axial Compressive Load.

20. ASTM D3689 - Standard Test Methods for Deep Foundations Under Static Axial Tensile Load.

21. ASTM D3966 - Standard Test Methods for Deep Foundations Under Lateral Load.

22. ASTM F3125 - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength, Inch Dimensions.

23. AWS B2.1 - Specification for Welding Procedure and Performance Qualification.

24. AWS D1.1 - Structural Welding Code.

25. AWS D1.4 - Structural Welding Code – Reinforcing Steel.

26. ICC AC358 - Acceptance Criteria for Helical Piles Systems and Devices.

27. OSHA Excavation Safety Guidelines.

28. SAE J429 - Mechanical and Material Requirements for Externally Threaded Fasteners.

B. Comply with all local building code requirements which are more stringent than those listed above. All referenced codes or standards shall be the most currently adopted as of the date for Receipt of Proposal.

C. Where any provision of other pertinent codes and standards conflict with this specification, the more stringent provision shall govern.

D. Fabrication and Installation Qualifications:

1. All welding of structural steel shall be performed by operators who have been recently qualified as prescribed in “Qualification Procedures” of the American Welding Society (AWS).

2. The Steel Helical Pile Contractor shall be fully experienced in all aspects of helical pile design and construction, and shall furnish all necessary materials, skilled labor, and supervision to carry out the contract. The Contractor shall not have less than five (5) years of continuous experience in fabrication and installation of steel helical pile work. Job supervisor shall have a minimum of three (3) years of method specific experience.

3. Upon request of the Architect/Engineer, Helical Pile Contractor shall submit evidence of successful installation of steel helical piles under similar project scope and size.

4. The Steel Helical Pile Contractor shall not sublet the whole or any part of the contract without the express permission in writing of the Owner.

E. Inspector shall keep a record or log of each pile as installed. Records shall show location, top and bottom elevations, shaft diameters, date installed, type of strata encountered, rated load capacity, grout pressure attained and any other pertinent information. A copy of this record shall be submitted to the Architect and Engineer for their record files.

F. Helical Pile Contractor shall schedule and provide time and means for the Inspection Agency to inspect, take samples, and make tests.

1.3 TESTING AND INSPECTION

A. Inspection and Testing:

1. The Contractor shall employ an Inspection Agency to perform the duties and responsibilities specified below.

2. Refer to architectural, civil, mechanical, and electrical specifications for testing and inspection requirements of non-structural components.

3. Work performed on the premises of a fabricator approved by the building official need not be tested and inspected per the table below. The fabricator shall submit a certificate of compliance that the work has been performed in accordance with the approved plans and specification to the building official and the Architect and Engineer of Record.

4. Duties of the Inspection Agency:

   a. Perform all testing and inspection required per approved testing and inspection program.

   b. Furnish inspection reports to the building official, the Owner, the Architect, the Engineer of Record, and the General Contractor. The reports shall be completed and furnished within 48 hours of inspected work.

   c. Submit a final signed report stating whether the work requiring Inspection was, to the best of the Inspection Agency's knowledge in conformance with the approved plans and specifications.

5. Structural Component Testing and Inspection Schedule for Section 31 26 00 is as follows:

Steel Helical Piles	Continuous	Periodic
Verify element materials, sizes, and lengths comply with the requirements.	X	
Determine capacities of test elements and conduct additional load tests, as required.	X	
Observe drilling operations and maintain complete and accurate records for each element.	X	
Verify placement locations and plumbness, confirm type and size of jack, record pressure per foot of penetration, determine required penetration to achieve design capacity, record tip and butt elevations and document any damage to foundation element.	X	

1.4 DEFINITIONS

A. A partial list follows:

1. Bearing Stratum: The soil or highly weathered rock layer that provides the axial tension resistance for the installed helical pile.

2. Brackets: Cap plate, angle, thread bar, or other termination device that is bolted or welded to the end of a helical pile after completion of installation to facilitate attachment to structures or embedment in cast-in-place concrete.

3. Crowd: Axial compressive force or pressure applied to the helical pile as needed during installation to ensure the pile advances into the ground a minimum of 80% of the distance equal to the helix pitch for each revolution.

4. Deflection: The axial displacement of the pile as measured at the pile head under applied load.

5. Effective Torsional Resistance: The average installation torque typically taken over a distance equal to the last three diameters of penetration of the largest helix plate as close to or in the specified bearing stratum.

6. Extension Section: Helical pile component connecting the lead section to the load transfer device. Extension sections may be plain without helix plates or helical including one or more helix plates.

7. Factored Load: Service load times the required load factor.

8. Geotechnical Capacity: The maximum load that can be resisted through the bearing of the helix plates in the soil or highly weathered rock in which they are embedded as characterized by the available subsurface soils, rock and groundwater information, and geotechnical testing data, without exceeding the specified performance criteria.

9. Helical Pile: Consists of one or more helix plates attached to a central shaft and load transfer device for attachment to a structure. May also include surface coating or other corrosion protection means.

10. Helical Anchor: Same as a Helical Pile. Term generally used when axial tension is the primary service load.

11. Helix Plate (Helices): Generally round steel plate formed into a helical spiral and welded to the central steel shaft.

12. Installation Angle: Angle of inclination between the longitudinal axis of the helical pile and the horizontal.

13. Lead Section: The first helical pile component installed into the soil. It consists of one or more helical plates welded to the central steel shaft.

14. Limit State: A condition beyond which a helical pile component or interface becomes no longer useful for its intended function (serviceability limit state) or to be unsafe (strength limit state).

15. Loads: Forces or other actions as defined that must be resisted by the piles. Permanent loads are those loads in which variations over time are rare or of small magnitude. All other loads are variable loads. Refer also to Service Load below.

16. Load Factor: A factor that accounts for deviations of the actual load from the service load (load resistance factor design).

17. Load Test: A procedure to test the capacity and relation of load to deflection by applying a compression, tension, and/or lateral load on the helical pile.

18. Mechanical Strength: The maximum compressive, tension, and/or lateral load capable of being resisted by the structural elements of a helical pile.

19. Pile Design Professional: Individual or firm responsible for the design of helical piles, helical anchors, and brackets.

20. Reveal: The distance from ground surface to the end of the last installed extension of a pile, measured along the pile's longitudinal axis.

21. Pitch: The distance measured along the axis of the shaft between the leading and trailing edges of the helix plate.

22. Safety Factor: The ratio of the ultimate resistance to the service load used for the design of any helical pile component or interface.

23. Service Load: The total magnitude of the unfactored loads, determined by the Owner's Representative, that must be resisted by the piles.

24. Torque: The measure of the rotational force times the moment arm needed to overcome the shear strength of the soil measured in ft-lb. Torque is used as an empirical approach for predicting the ultimate capacity of a helical pile.

25. Ultimate Resistance: Limit state based on the lesser of mechanical strength or geotechnical capacity of the helical pile defined as the point at which no additional load can be applied without exceeding the specified performance criteria.

1.5 DESIGN

A. Helical pile design shall be designed to meet the specified loading as shown on the drawings and deflection criteria of 1/2" differential settlement and 1" total settlement. Calculations and drawings required from the Helical Pile Contractor shall be submitted to the Architect/Engineer.

B. Helical pile design shall include overall pile length, helix length, and helix configuration. If static load testing is performend, pile design to include a minimum factor of safety of 2.0. If static load testing is not performend, pile design to include a minimum factor of safety of 3.0.

C. Except where noted in the drawings, all pile components shall be designed to provide a minimum safety factor for mechanical strength of 2.0.

D. Except where noted in the drawings, each pile shall be designed to meet a corrosion service life of 50 years.

E. The helical pile design shall take into account pile spacing, soil stratification, long-term soil consolidation, corrosion, settlement, and strain compatibility issues as are present for the project.

F. The helical pile top attachment shall effectively distribute the design load to the concrete foundations such that the concrete bearing stress does not exceed those in the ACI Building Code and the bending stress in the steel plates does not exceed AISC allowable stresses for steel members.

G. If on-site load testing is to be performed, the piles shall be designed such that the maximum test load does not exceed 90% of the manufacturer's rated mechanical strength of any pile component or load transfer device.

1.6 BID REQUIREMENTS

A. Steel Helical Piles: Bids shall be provided for the lump sum amount based on the number of piles, estimated length, and total footage as shown in the drawings and/or specifications.

B. The Pile Contractor shall examine the construction site and conditions under which piles are to be installed, and notify the General Contractor and Architect in writing prior to bidding of any conditions detrimental to proper and timely completion of work.

C. Helical Pile Length: Base the length of the helical piles on the length listed on the drawings and in the Geotechnical Engineering Report. The elevation identifying the bottom of the shaft is an approximate length for consistent bidding purposes only. The actual length will be determined in the field from the actual elevation of the bearing stratum to be verified by the Inspection Agency.

D. Unit prices shall be issued to the Architect prior to construction as part of the submittal package.

E. Adjustments in the Contract Price will be made due to changes in the number and length of piles, based on unit prices established in Section 01 21 00 - Allowances as follows:

1. Payment for helical piles will be made on the total length of helical piles installed and accepted. Actual length and shaft diameter may change due to job conditions. Adjusted payment will be made on the basis of net variations to the total quantities, based on design dimensions.

2. Provide the following unit costs in the event that additions to, or deductions from, work, are required and authorized in writing by Architect/Engineer:

    a. Additional length of helical pile ($/per foot)
    b. Subtracted length of helical pile ($/per foot)
    c. Load test (lump sum per test)

1.7 SUBMITTALS

A. Shop Drawings:

1. Prepare and submit to the Architect/Engineer, for review and approval, working drawings and relevant structural design calculations for the helical pile system or systems intended for use. All design submittal shall be sealed by a Registered Professional Engineer currently licensed in the state where the project is located.

2. Product Data:

    a. Product designations for helix sections, extension sections, and all ancillary products to be supplied at each helical pile location.
    b. Evaluation approved by the applicable building code authority (e.g., International Code Council Evaluation Services (ICC-ES)).
    c. Corrosion protection and pile top attachment.
    d. Manufacturer’s published mechanical strengths for the pile assemblies, including load transfer devices per current ICC-ES report, calculations, and/or full scale testing.

3. Design Data:

    a. Calculated geotechnical capacity of piles based on geotechnical information. The design submittal prepared by the pile designer shall indicate that the selected piles can be installed to achieve the performance requirements.
    b. Minimum effective torsional resistance criteria.
    c. Maximum allowable installation torque of pile.
    d. Proposed production quality control plan, including method and equipment to be used to measure torsional resistance during installation.

e. Procedures and acceptance criteria for any proposed performance and/or proof testing.

4. Submit a detailed description of the construction procedures proposed for use to the Architect/Engineer for review. This shall include a schedule of major equipment resources.

5. The working drawings shall include helical pile installation details giving:

a. Helical pile number, location, and pattern by assigned identification number
b. Helical pile design load
c. Type and size of central steel shaft
d. Number and diameter of helix plates
e. Minimum overall length
f. Minimum effective installation torque
g. Inclination of helical pile
h. Helical pile attachment to structure relative to grade beam, pile cap, etc.
i. Cutoff elevation

6. Submit shop drawings for all structural steel, including the helical pile components, corrosion protection system, pile top attachment, and helix details, to the Architect/Engineer for review and approval.

7. Submit for review and acceptance the proposed helical pile load testing procedure. The testing program shall be provided two (2) weeks prior to starting the load testing. This helical pile verification load testing proposal shall be in general conformance with ASTM D1143 and/or D3689, and shall indicate the minimum following information:

a. Type and accuracy of apparatus for measuring load
b. Type and accuracy of apparatus for applying load
c. Type and accuracy of apparatus for measuring the pile deformation
d. Type and capacity of reaction load system, including sealed design drawings
e. Hydraulic jack calibration report

8. Submit to the Architect/Engineer calibration reports for each test jack, pressure gauge, and master pressure gauge to be used. The calibration tests shall have been performed by an independent testing laboratory, and tests shall have been performed within one year of the date submitted. Testing shall not commence until the Architect/Engineer has approved the jack, pressure gauge, and master pressure gauge calculations.

9. Work shall not begin until the appropriate submittals have been received, reviewed, and approved in writing by the Architect/Engineer. Note that any additional time required due to incomplete or unacceptable submittals shall not be cause for delay or impact claims. All costs associated with incomplete or unacceptable submittals shall be the responsibility of the Contractor.

10. Welding certificates.

11. Unit costs: Submit as outlined in this section.

12. The Contractor shall submit to the Architect copies of calibration reports for each torque indicator or torque motor, and all load test equipment to be used on the project. The calibration tests shall have been performed within 45 working days of the date submitted. Helical pile installation and testing shall not proceed until the Architect/Engineer has received the calibration reports. These calibration reports shall include, but are not limited to, the following information:

a. Name of project and Contractor
b. Name of testing agency
c. Identification (serial number) of device calibrated
d. Description of calibrated testing equipment

e. Date of calibration
f. Calibration data

13. Installation Reports: The installing contractor shall provide the Owner, or his authorized representative, copies of individual helical pile installation records within 24 hours after each installation is completed. Formal copies shall be submitted within 48 hours after installation. These installation records shall include, but are not limited to, the following information:

a. Name of project and Contractor
b. Name of Contractor's supervisor during installation
c. Date and time of installation
d. Installation equipment type and operator name
e. Type of torque indicator used
f. Location of helical pile or helical anchor by grid location, diagram, or assigned identification number
g. Pile reveal
h. Type and configuration of lead section with length of shaft and number and size of helical bearing plates
i. Type and configuration of extension sections with length and number and size of helical bearing plates, if any
j. Final elevation of top of shaft and cutoff length, if any
k. Total length of installed pile
l. As-built installation angle of pile
m. Torque measurements at three-foot depth intervals
n. Final installation torque
o. Effective torsional resistance and calculated geotechnical capacity based on effective torsional resistance and/or as derived from the pre-production test program
p. Comments pertaining to interruptions, obstructions, or other relevant information
q. Unless specified otherwise on the drawings or by local codes, the pile design professional, or an inspection agency accepted by the Architect/Engineer, shall observe and document at least 10 percent of helical pile and helical anchor installations.

B. LEED Certification: Submit manufacturer's certification for each steel product including the following:

1. LEED Credit MRc 4.1/4.2 – Recycled content, including percentage of pre-consumer (post-industrial) and post-consumer recycled content. Also provide manufacturer's name, product cost and steel processing furnace type.

2. LEED Credit MRc 5.1/5.2 – Location of manufacturing plant, manufacturer's name, product cost and location of extraction or harvest of raw materials.

C. Post Construction:

1. The following records shall be prepared for the Owner. The records shall be completed within 24 hours after each pile installation is completed. The records shall include the following minimum information:

a. Pile drilling duration and observations
b. Information on soil and rock encountered, including description of strata, water, etc.
c. Approximate final tip elevation
d. Cutoff elevation
e. Rated load capacities
f. Description of unusual installation behavior or conditions
g. Any deviations from the intended parameters
h. Torque attained, where applicable
i. Pile materials and dimensions
j. Helical pile test records, analysis, and details

2. Submit as-built drawings showing the location of the piles, their depth and inclination, and details of their composition.

1.8 SUBSURFACE CONDITIONS

A. The Geotechnical Report, including logs of soil borings as shown on the boring location plan, shall be considered to be representative of the in-situ subsurface conditions likely to be encountered on the project site. Said Geotechnical Report shall be the used as the basis for helical pile design using generally accepted engineering judgment and methods.

B. The Geotechnical Report shall be provided for purposes of bidding. If, during helical pile installation, subsurface conditions of a type and location are encountered of a frequency that were not reported, inferred, and/or expected at the time of preparation of the bid, the additional costs required to overcome such conditions shall be considered as extras to be paid for by the Owner.

1.9 PILE LOAD TESTING

A. If pile testing is required, the Installing Contractor shall furnish all labor, equipment, and pre-production helical piles necessary to accomplish the testing as shown in the previously submitted and approved pile design submittals. The Installing Contractor shall apply the specified loads for the specified durations and record the specified data for the specified number of piles. No deviations from the test plan(s) will be allowed without explicit approval in writing from the Owner/Owner's Representative. Pile testing shall be in accordance with the load testing procedures and performance requirements deemed suitable for the application by the Owner/Owner's Representative, or pile designer.

B. Helical Pile Compression Tests:

1. Contractor shall perform the number of compression tests shown on the drawings.

2. Compression tests shall be performed following the "quick test" procedure described in ASTM D1143 specifications.

3. Load tests shall be observed and documented by the Inspection Agency.

4. Unless otherwise shown on the drawings, the maximum test load shall be 200% of the allowable load shown on the drawings.

5. The locations of helical piles to be tested shall be determined by the Contractor, unless noted on the drawings.

6. Installation methods, procedures, equipment, products, and final installation torque shall be identical to the production helical piles to the extent practical, except where otherwise approved by the Owner or Architect/Engineer.

7. A load test shall be deemed acceptable provided the maximum test load is applied without helical pile failure and the deflection of the pile head at the design load is less than 1-inch, unless noted otherwise on the drawings. Failure is defined when continuous jacking is required to maintain the load.

C. If a load test fails the foregoing acceptance criteria, the Contractor shall modify the helical pile or helical anchor design and/or installation methods and retest the modified pile or anchor as directed by the Owner or Architect/Engineer. These modifications include, but are not limited to, de-rating the load capacity, modifying the installation methods and equipment, increasing the minimum final installation torque, changing the helical configuration, or changing the product (e.g., duty). Modifications that require changes to the structure shall have prior review and acceptance of the Owner. Any modifications of design or construction procedures, and any retesting required, shall be at the Contractor's expense.

D. The Contractor shall provide the Owner and Architect/Engineer copies of load test reports confirming configuration and construction details within one (1) week after completion of the load tests. This written documentation will either confirm the load capacity as required on the working drawings or propose changes based on the results of the tests. At a minimum, the documentation shall include, but is not limited to, the following information:

1. Name of project and installing contractor
2. Name of installing contractor's supervisor during installation
3. Name of third party test agency, if any
4. Type of test, pre-production or production test
5. Date, time, and duration of test
6. Unique identifier and location of helical pile tested
7. Test procedure (ASTM D1143, D3689, or D3966)
8. List of any deviations from procedure
9. Test criteria, performance or proof
10. Description of calibrated testing equipment and test setup
11. Testing equipment calibration data
12. Type and configuration of helical pile or helical anchor including lead section, number and type of extension sections, and manufacturer's product identification numbers
13. Load steps and duration of each load increment
14. Incremental and cumulative pile-head movement at each load step
15. Comments pertaining to test procedure, equipment adjustments, or other relevant information
16. Reaction frame/pile installation and verification data, as required by Owner or pile designer
17. Incremental and cumulative pile-head movement at each load step
18. Signatures as required by local jurisdiction

1.10 PRODUCT DELIVERY, STORAGE AND HANDLING

A. All helical pile, helical anchor, and bracket assemblies shall be free of structural defects and protected from damage. Store helical piles, helical anchors, and bracket assemblies on wood pallets or supports to keep from contacting the ground. Damage to materials shall be cause for rejection.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. AB Chance Company, a subsidiary of Hubbel Corp., 210 North Allen Street, Centralia, MO 65240-1395; or Aluma-Form/Dixie, 3625 Old Getwell Road, Memphis, TN 38118.

B. Foundation Supportworks®, Inc., 12330 Cary Circle, Omaha, NE 68128.

C. Pier Tech Systems, 17813 Edison Avenue, Suite 100, Chesterfield, MO 63005.

D. Magnum Piering, Inc., 6082 Schumacher Park Drive, West Chester, OH 45069.

2.2 LEED CREDIT

A. LEED Credit MRc 4.1/4.2:

1. Steel products shall be made using an electric arc furnace and shall have a minimum recycled content of 80%, including at least 65% post-consumer recycled content and 15% post-industrial recycled content.

2. Steel products made using a basic oxygen furnace shall have a minimum recycled content of 25%, including at least 20% post-consumer recycled content and 5% post-industrial recycled content.

B. LEED Credit MRc 5.1/5.2:

1. Steel products shall be manufactured within 500 miles of project site. Recycled scrap products shall be procured from within 500 miles of the project site.

PART 3 - EXECUTION

3.1 SITE CONDITIONS

A. Prior to commencing helical pile installation, the Contractor shall inspect the work of all other trades and verify that all said work is completed to the point where helical piles may commence without restriction.

B. The Contractor shall verify that all helical piles may be installed in accordance with all pertinent codes and regulations regarding such items as underground obstructions, right-of-way limitations, utilities, etc.

C. In the event of a discrepancy, the Contractor shall notify the Architect/Engineer. The Contractor shall not proceed with helical pile installation in areas of discrepancies until said discrepancies have been resolved. All costs associated with unresolved discrepancies shall be the responsibility of the Owner.

3.2 INSTALLATION

A. Installing Contractor shall furnish and install all helical piles per the project plans and approved pile design submittals. In the event of conflict between the project plans and the approved pile design documentation, the Installing Contractor shall not begin construction on any affected items until such conflict has been resolved.

B. Installation of helical piles may be observed by representatives of the Owner for quality assurance purposes. The Installing Contactor shall notify the Owner's Representative at least 24 hours prior to pile installation operations. All helical pile sections and ancillary products shall be marked as necessary to allow correlation with the pile design submittals before shipment from the manufacturer.

C. The helical pile installation technique shall be such that it is consistent with the geotechnical, logistical, environmental, and load carrying conditions of the project. The lead section shall be positioned at the location as shown on the pile design drawings. Inclined helical piles can be positioned perpendicular to the ground to assist in initial advancement into the soil before the required installation angle shall be established. After initial penetration, the required installation angle shall be established. The helical pile sections shall be engaged and advanced into the soil in a smooth, continuous manner at a rate of rotation of 5 to 25 rpm. Sufficient crowd shall be applied to uniformly advance the helical pile sections a minimum of 80% of the distance equal to the pitch of the helix plate per revolution. The rate of rotation and magnitude of crowd shall be adjusted for different soil conditions and depths. Extension sections shall be provided to obtain the required minimum overall depth/length and minimum effective torsional resistance as shown on the project plans.

3.3 TERMINATION CRITERIA

A. The specified minimum overall depth/length criteria and minimum effective torsional resistance criterion must be satisfied prior to terminating the helical pile installation. In the event any helical pile fails to meet these production quality control criteria, the following pre-qualified remedies are authorized:

1. If the installation fails to meet the minimum effective torsional resistance criterion at the minimum embedment depth/length:

a. Continue the installation to greater depth/length in the specified bearing stratum until the effective torsional resistance criterion is met, provided continued installation does not exceed any applicable maximum length. or,

b. Demonstrate acceptable pile performance through load testing. or,

c. Replace the pile with one having a different helix configuration. The replacement pile must not exceed any applicable maximum embedment length and either be embedded to a length that places its last helix at least three times its own diameter beyond the position of the first helix of the replaced pile and meet the minimum effective torsional resistance criterion, or pass load testing.

2. If the torque measured during installation reaches the helical pile's allowable torque rating prior to reaching the minimum embedment depth/length criterion, with approval from the Owner/Owner's Representative, terminate the installation, then proceed with one of the following recommended actions:

a. Replace the pile with one having a shaft with a higher torsional strength rating. This replacement pile must be installed to satisfy the minimum embedment depth/length criterion. It must also be embedded to a depth/length that places its last helix at least three times its own diameter beyond the position of the first helix of the replaced pile without exceeding any applicable maximum embedment depth/length requirements, and it must meet the minimum effective torsional resistance criterion. or,

b. Replace or modify the pile with one having a different helix configuration. This replacement or modified pile must be installed to satisfy the minimum embedment depth/length criterion. It must also be embedded to a depth/length that places its last helix at least three times its own diameter beyond the position of the first helix of the replaced pile without exceeding any applicable maximum embedment depth/length requirements, and it must meet the minimum effective torsional resistance criterion. or,

c. If allowed or approved by the Owner/Owner's Representative, remove and reinstall the pile at a position at least three times the diameter of the largest helix away from the initial location. Original minimum embedment depth/length and effective torsional resistance criteria must be met for the repositioned pile. This pile repositioning may require the installation of additional helical piles with service loads adjusted for these spacing changes.

3. If the installation reaches a specified maximum embedment depth/length without achieving the minimum effective torsional resistance criterion:

a. If approved by the Owner/Owner's Representative, remove and reinstall the pile at a position at least three times the diameter of the largest helix away from the initial location. Original minimum installation depth/length and effective torsional resistance criteria must be met for the repositioned pile. This pile repositioning may require the installation of additional helical piles with service loads adjusted for these spacing changes. or,

b. Demonstrate acceptable pile performance through load testing. or,

c. Reduce the load capacity of the helical pile and install additional pile(s) as necessary. The reduced capacity and additional pile location shall be subject to the approval of the Owner/Owner's Representative. or,

d. Replace the pile with one having a different helix configuration. This replacement pile must be embedded to a depth/length that places its last helix at least three times its own diameter beyond the position of the first helix of the replaced pile. This replacement pile must be installed to satisfy the minimum embedment depth/length criterion, and it must meet the minimum effective torsional resistance criterion.

4. If a helical pile fails to meet acceptance criteria in a load test:

a. Install the pile to a greater depth/length and installation torque and re-test, provided any maximum embedment depth/length criterion is not exceeded. or,

b. Replace the pile with one having more and/or larger helix plates. It must be embedded to a depth/length that places its last helix at least three times its own diameter beyond the position of the first helix of the replaced pile without exceeding any applicable maximum embedment depth/length requirements. This replacement pile must be re-tested. or,

c. If approved by the Owner's Representative, de-rate the load capacity of the helical pile and install additional piles. Additional piles must be installed at positions at least three times the diameter of the largest helix away from any other pile locations and approved by the Owner's Representative. Piles installed in cohesive soils shall not be spaced closer than four helix diameters.

5. Load testing to qualify a helical pile under any of the remedial actions outlined in Article 1.9 shall not be used to satisfy load testing frequency requirements shown in the project plans or the approved design submittals.

6. If a helical pile fails a production quality control criterion for any other reason, including damage during installation, any proposed remedy must be approved by the Owner/Owner's Representative prior to implementation.

3.4 TOLERANCES

A. When helical pile placement is shown on the project plans, production piles shall be placed such that the pile head is within 3 inches laterally and longitudinally and 1/2 inch vertically to plan; and the pile shaft alignment is within 1 degree of the installation angle shown on the project plans. When pile placement is not shown on the project plans, the placements, alignments, and their respective tolerances shall be included as part of the design submittal.

3.5 CLEANUP

A. The Installing Contractor shall remove any and all material, equipment, tools, building materials, concrete forms, debris, or other items belonging to the Installing Contractor or used under the Installing Contractor's direction.

END OF SECTION

SECTION 31 66 13
SHORT AGGREGATE PIER FOUNDATION SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. The General and Supplementary Conditions of the Construction Contract and Division 1 - General Requirements apply to the Work specified in this section.

B. This Section includes the excavation and construction of short aggregate piers as shown on the Drawings and specified herein.

1. Short aggregate piers shall be defined as columnar-type foundation piers constructed by compacting aggregate with special high-energy impact densification equipment into an excavated shaft to produce an intermediate foundation system for support of foundation loads. The term "pier" shall be used in this section to refer to short aggregate piers.

2. Aggregate piers referenced in this specification refer to both rammed piers and vibro stone columns.

C. Furnish and install all aggregate, reinforcing steel and other accessories as shown on the drawings and herein specified.

D. Structural notes indicated on the drawings regarding short aggregate pier foundation systems shall be considered a part of this specification.

1.2 REFERENCE STANDARDS

A. Design:

1. "Control of Settlement and Uplift of Structures Using Short Aggregate Piers," by Evert C. Lawton (Assoc. Prof., Dept. of Civil Eng., Univ. of Utah), Nathaniel S. Fox (President, Geopier Foundation Co., Inc.), and Richard L. Handy (Distinguished Prof. Emeritus, Iowa State Univ., Dept. of Civil Eng.), reprinted from IN-SITU DEEP SOIL IMPROVEMENT, Proceedings of sessions sponsored by the Geotechnical Engineering Division/ASCE in conjunction with the ASCE National Convention held October 9-13, 1994, Atlanta, Georgia.

2. "Settlement of Structures Supported on Marginal or Inadequate Soils Stiffened with Short Aggregate Piers," by Evert C. Lawton and Nathaniel S. Fox. Geotechnical Special Publication No. 40: Vertical and Horizontal Deformations of Foundations and Embankments, ASCE, 2, 962-974.

1.3 DESIGN REQUIREMENTS

A. The design submitted by the Aggregate Pier Installer shall consider the bearing capacity and settlement of all footings supported by the aggregate piers, and shall be in accordance with acceptable Engineering practice and these specifications. Total and differential settlement shall be considered. The design life of the structure shall be 50 years, unless specified by the Owner.

B. Aggregate Pier Design:

1. Aggregate piers shall be designed in accordance with generally accepted Engineering practices and the method described in "Control of Settlement and Uplift of Structures Using Short Aggregate Piers." The design shall also meet the following criteria:

a. Maximum Allowable Bearing Pressure: 5,000 psf for Aggregate Pier Improved Soil.

b. Minimum Aggregate Pier Area Coverage (Spread Footings): 30%.

c. Maximum Total Long-Term Settlement for Footings: ≤ 1 inch.

d. Maximum Long-Term Differential Settlement: ≤ 0.5 inches for Adjacent Footing.

C. Capacity and Size of the Aggregate Piers:

1. The Installer shall be responsible for delivering a system that will support the structure, while controlling settlement in accordance with these specifications. The Engineer shall approve any modifications in size and spacing of the aggregate piers, unless such modifications result in more conservative design, in which case the Installer may approve them.

D. Design Submittal:

1. The Aggregate Pier Installer shall submit 4 sets of detailed design calculations, construction drawings, and shop drawings for approval at least 2 weeks prior to the beginning of construction. A detailed explanation of the design properties for settlement calculations shall be submitted with the design. Additionally, the quality control test program for the aggregate piers, meeting these design requirements, shall be submitted. All computer-generated calculations and drawings shall be prepared and sealed by a Professional Engineer, licensed in the State or Province where the piers are to be built.

1.4 QUALITY ASSURANCE

A. Codes and Standards: Comply with the provisions of the following codes, specifications and standards, except where more stringent requirements are shown or specified.

1. Modulus Load Testing:

a. ASTM D1143 – Pile Load Test Procedures

2. Materials and Inspection:

a. ASTM D1241 – Aggregate Quality
b. ASTM STP-399 – Dynamic Penotrometer Testing
c. ASTM D422 – Gradation of Soils

B. Where any other pertinent code or specification conflicts with this specification, the more stringent will govern.

C. All piers shall be installed by a Contractor specializing in the installation of short aggregate piers, and who shall have a minimum 5 years of documented experience in the field of aggregate pier construction.

D. Pier Contractor shall keep a record or log of each pier as installed. Records shall show location, top and bottom elevations, shaft and bulb diameters, date pier is filled, type of strata encountered, and any other pertinent information. A copy of this record shall be submitted to the Architect and Structural Engineer for their record files.

E. Contractor shall schedule and provide time and means for the Inspection Agency to inspect, take samples and make tests.

1.5 TESTING AND INSPECTION

A. Inspection and Testing:

1. The Contractor shall employ an Inspection Agency to perform the duties and responsibilities specified below.

2. Refer to architectural, civil, mechanical, and electrical specifications for testing and inspection requirements of non-structural components.

3. Work performed on the premises of a fabricator approved by the building official need not be tested and inspected per the table below. The fabricator shall submit a certificate of compliance that the work has been performed in accordance with the approved plans and specification to the building official and the Architect and Engineer of Record.

4. Duties of the Inspection Agency:

   a. Perform all testing and inspection required per approved testing and inspection program.

   b. Furnish inspection reports to the building official, the Owner, the Architect, the Engineer of Record, and the General Contractor. The reports shall be completed and furnished within 48 hours of inspected work.

   c. Submit a final signed report stating whether the work requiring Inspection was, to the best of the Inspection Agency's knowledge in conformance with the approved plans and specifications.

5. Structural Component Testing and Inspection Schedule for Section 31 66 13 is as follows:

Short Aggregate Pier Foundation System	Continuous	Periodic
Verify element materials, sizes, and lengths comply with the requirements.	X	
Determine capacities of test elements and conduct additional load tests, as required.	X	
Observe driving operations and maintain complete and accurate records for each element.	X	
Verify placement locations and plumbness, confirm type and size of hammer, record number of blows per lift and document any soil that fell into the aggregate pier.	X	

1.6 UNIT PRICES

A. Unit prices shall be issued to the Architect prior to construction as part of the submittal package.

B. Aggregate Pier Size Length and Quantity: The Aggregate Pier Contractor shall determine the exact size, length and quantity of piers for this project as part of their design services. Piers shown on the drawings are a schematic representation of what is anticipated for the final design and is used for coordination purposes only.

   1. Field adjustments to the pier length may be required due to the actual elevation of the bearing stratum verified by the Inspection Agency and Pier Contractor.

C. Adjustments in the Contract Price will be made due to changes in the number and length of piers, based on unit prices established in this Agreement as follows:

   1. Payment for piers will be made on final length of piers in place and accepted. Actual length and pier diameter may change due to job conditions. Adjusted payment will be made on the basis of net variations to the total quantities, based on design dimensions.

2. Provide the following unit costs in the event that additions to, or deductions from, work are required and authorized in writing by Architect/Engineer:

a. Additional length of aggregate pier ($/per lineal feet)

b. Subtracted length of aggregate pier ($/per lineal feet)

1.7 SUBMITTALS

A. The Aggregate Pier Installer shall submit detailed design calculations and construction drawings to the Owner or Owner's Engineer for approval at least 1 week prior to the start of construction. A Professional Engineer licensed in the State where the project is located shall seal all plans and calculations prepared under their supervision.

B. The Aggregate Pier Installer shall submit a notarized manufacturer's certification prior to the start of work, stating that the aggregate and other materials used meet the requirements of this specification.

C. Daily Aggregate Pier Progress Reports – The Testing Agency shall furnish a complete and accurate record of aggregate pier installation to the General Contractor. The record shall indicate the pier location, length, average lift thickness, and final elevations of the base and top of pier. The record shall also indicate the type and size of the densification equipment used. The Aggregate Pier Installer shall immediately report any unusual conditions encountered during the installation to the General Contractor, to the aggregate pier designer, and to the Testing Agency.

D. Post Construction:

1. The Inspector shall prepare and submit the daily aggregate pier progress report as described earlier to the Architect and one file copy to the Structural Engineer of Record.

2. The Pier Contractor shall prepare and submit their record or log of the pier installation as described earlier to the Architect and one file copy to the Structural Engineer of Record.

3. Prepare and submit results of all tests and inspections.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Aggregate shall be Type 1 Grade B in accordance with ASTM D1241

1. Aggregate to be compacted to a densification and strength, which provides resistance to the dynamic penetration test (ASTM STP-399) of a minimum average of 15 blows per 1.75-inch vertical movement.

2. The number of tests performed during a workday by the testing agency shall depend on the consistency of achieving the minimum penetration resistance. Penetration test need not be performed on every pier if average penetration resistances measured exceed 15 blows, and less than 10% of tests fall below 15 blows, then testing may be reduced to spot checks.

3. Observation of questionable aggregate moisture content or questionable aggregate gradation appearance may determine the need for additional dynamic penetration testing to verify that proper densification and strength are being achieved.

B. Aggregate for piers below the water table shall be the same as Type 1 Grade B except that particles passing through the No. 40 sieve shall be eliminated. Pier installer may submit for approval an alternate stone gradation for this type of installation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. General Contractor and Pier Contractor shall examine all Drawings pertaining to this work and shall visit the work site before completing their bids. Verify that site conditions will support equipment required to install piers.

3.2 PREPARATION

A. General Contractor shall conduct all excavating, filling and grading necessary to leave site ready to receive pier work.

B. Situate equipment as to not cause damage to adjacent structures. Contractor to protect adjacent structures from damage if required.

C. Pier Contractor shall be responsible for all shoring, cribbing and planning necessary or required for supporting and manipulating their equipment.

D. Where unstable or unsuitable soils are located, equipment supports shall be keep at least 10 feet away from the pier location to prevent compression or shearing of soil at the top of the pier wall or provide temporary steel casings of adequate strength to protect the excavation from collapse.

E. Pier Contractor shall examine the soil boring logs of geotechnical report prior to design and bidding.

F. In the event that the Pier Contractor hits obstructions, which cannot be removed with standard soil drilling tools, the General Contractor shall seek approval from the Architect to remove the obstruction on a unit price basis. An obstruction shall be defined as any object (boulder, rock, concrete, etc.), which prevents the pier construction with standard soil drilling equipment. Inspector shall determine if objects encountered are classified as obstructions.

3.3 FIELD MEASUREMENT

A. General Contractor shall field locate each pier relative to the building lines and column centerlines.

3.4 INSTALLATION – STONE COLUMNS

A. Install stone columns with a down-hole vibrator capable of densifying the aggregate by forcing it radially into the surrounding soil. The vibrator shall be of sufficient size and capacity to construct stone columns to the diameters and lengths shown on the installer's approved construction drawings.

B. The probe and follower tubes shall be of sufficient length to reach the elevations shown on the installer's approved construction drawings. The probe, used in combination with the available pressure to the tip jet, shall be capable of penetration to the required tip elevation. Pre-boring shall be permitted if it is specified in the installer's approved construction procedure submittal.

C. The probe and follower shall have visible markings at regular increments to enable measurement of penetration and repenetration depths.

D. Provide methods for supplying to the tip of the probe a sufficient quality of air or water to widen the probe hole to allow adequate space for stone backfill placement around the probe.

E. The probe shall penetrate into the foundation soil layer to the minimum depths required in the installer's construction plans.

F. Lift thickness shall not exceed 4 feet. After penetration to the treatment depth, slowly retrieve the vibrator in 12-inch to 18-inch increments to allow backfill placement.

G. Compact the backfill in each lift by repenetrating it at least twice with the vibrating probe to densify and force the stone into the surrounding soil.

H. Install stone columns so that each completed column is continuous throughout its length.

3.5 INSTALLATION – RAMMED PIERS

A. The piers shall be accurately centered at the proper location and installed plumb.

B. All rammed aggregate pier elements shall be pre-augered using mechanical drilling or excavation equipment. Installation of piers without pre-augering shall not be allowed, because this technique results in significant disturbance and remolding of the matrix soils surrounding the piers.

C. Bottom Stabilization Verification Test – After completion of the bottom pier bulb, or at any time during the process of constructing the pier, the energy source may be turned off, and a bottom stabilization verification test may be performed. These tests shall be performed when a new soil formation is encountered, or at the beginning of a project to provide quantitative information on pier stabilization. A reference bar is placed over the cavity, and a mark is made on the tamper shaft that has been placed on top of the compacted aggregate. The energy to the tamper is restarted. If the measured vertical movement exceeds 150% of the value achieved during the load test, added energy is applied to densify the bulb. The procedure for measuring is then repeated. If there is still movement greater than 150% of that achieved during the load test greater than ½ inch, a lift of loose aggregate may be placed on top of the compacted aggregate, and the verification test may be performed on this next lift after it is densified. Movement must be limited to 150% of the values achieved for the load test before completion of 2/3 of the pier depth unless unusually powerful modified hydraulic hammers are being used with tamper heads smaller than 26 inches in diameter.

D. Debris shall be removed from the bottom the shaft by mechanical methods and not by the trade contractor's personnel. At no time shall any field personnel access the pier excavation.

E. If cave-ins occur during excavation such that the sidewalls of the hole are deemed to be unstable, steel casing or a drilling slurry shall be used to stabilize the excavation.

F. If cave-ins occur on top of a lift of aggregate such that the volume of the caved soils is greater than 10 percent of the volume of the aggregate in the lift, then the aggregate shall be considered contaminated and shall be removed and replaced with uncontaminated aggregate.

G. Special high-energy impact densification apparatus shall be employed to densify the aggregate pier elements during installation. The apparatus shall apply direct downward impact energy to each lift of aggregate.

H. A minimum tamper energy level of 250,000 foot-pounds of force per minute shall be applied by the energy source.

I. Remove and dispose of excavated material as directed in Division 31 of this specification.

J. Excavations shall not be left open overnight.

K. Remove any water from shaft prior to aggregate placement.

L. Place aggregate in 1-foot lifts and compact with 45 degree beveled tampered head.

M. Each lift of aggregate shall be tamped for a minimum of 15 seconds.

3.6 TOLERANCES

A. The maximum variation in top elevation of the center of any pier shall be plus 1 inch and minus 3 inches at the cut off elevation.

B. The center of each pier shall be within six inches of the plan locations indicated.

C. The final measurement for the top of aggregate piers shall be the lowest point on the aggregate in the last compacted fill.

D. Piers installed outside the above tolerances and deemed not acceptable shall be rebuilt at no additional expense to the Owner.

3.7 FOOTING BASE PREPARATION

A. All excavations for footing bottoms supported by aggregate pier foundations shall be prepared in the following manner by the Concrete Foundation Contractor:

1. Over excavation below the bottom footing elevation shall be limited to 3 inches. This includes limiting the teeth from excavators from over excavation beyond 3 inches below the footing elevation.

2. Compaction of surface soil and top of aggregate piers shall be prepared using a standard, hand-operated impact compactor. Compaction shall be performed over the entire footing bottom to compact any loose surface soil and loose surface pier aggregate.

3. Footing excavations shall be inspected by the Inspector before placing concrete. Refer to Section 31 23 00 for compaction requirements.

4. Excavation and surface compaction of all footings shall be the responsibility of the Concrete Foundation Contractor.

END OF SECTION

SECTION 32 05 00
COMMON WORK RESULTS FOR EXTERIOR IMPROVEMENTS

PART 1 - GENERAL

1.1 SCOPE

A. This section includes information common to all site work and applies to the entire contract.

B. Unless otherwise noted in the Contract Documents, Contractor shall be responsible for obtaining and paying for all permits necessary to complete the work.

C. Construction Limits are indicated on the drawings. In the absence of such a designation on the drawings, confine work to the minimum area reasonably necessary to undertake the work as determined by the Construction Representative. In no case shall construction activities extend beyond property lines or construction easements.

D. The Contractor shall restore all disturbed areas in accordance with the drawings and specifications. If plans and specifications do not address restoration of specific areas, these areas will be restored to pre-construction conditions as approved by the Construction Representative.

1.2 REFERENCE STANDARDS

A. Work under this section depends on applicable provisions from other sections and the plan set in this contract. Examples of related sections include, but are not limited to:

1. Division 31 — Earthwork

2. Specification 01 76 00 Protecting Installed Construction

B. AASHTO - American Association of State Highway and Transportation Officials

C. ACPA - American Concrete Pipe Association

D. ANSI - American National Standards Institute

E. ASCE - American Society of Civil Engineers

F. ASME - American Society of Mechanical Engineers

G. ASTM - American Society for Testing and Materials

H. AWWA - American Water Works Association

I. AWS - American Welding Society

J. FHA - Federal Highway Administration

K. EPA - Environmental Protection Agency

L. NEC - National Electric Code

M. NEMA - National Electrical Manufacturers Association

N. NFPA - National Fire Protection Association

O. NSF - National Sanitation Foundation

P. OSHA - Occupational Safety and Health Administration

Q. STI - Steel Tank Institute

R. UL - Underwriters Laboratories Inc.

S. WDNR - State of Wisconsin Department of Natural Resources

T. WisDOT - State of Wisconsin Department of Transportation

U. Where reference is made to the "SSHSC", it shall mean the pertinent sections of the State of Wisconsin, Department of Transportation, Standard Specifications for Highway and Structure Construction, current edition, and all supplemental and interim supplemental specifications. Where reference is made to the "STANDARD SPECIFICATIONS", it shall mean pertinent sections of the City of Madison Standard Specifications for Public Works Construction, current edition. Where reference is made to the "BMPH", it shall mean the Wisconsin Construction Site Best Management Practice Handbook, current edition as published by the WDNR. Method of measurement and basis of payment sections in referenced documents shall not apply.

PART 2 - PRODUCTS

2.1 BARRICADES, SIGNS, AND WARNING DEVICES

A. Traffic barricades, traffic signs, and warning devices shall meet the requirements of applicable OSHA standards and the FHA Manual of Uniform Traffic Control Devices (MUTCD).

B. Traffic signing materials shall meet the requirements of Sections 634, 636, and 637 of Standard Specifications for Highway Construction except that signs shall be from aluminum blanks.

C. Galvanized 2" round posts shall be provided for all signs.

2.2 TEMPORARY PLASTIC BARRIER FENCING

A. UV stabilized high-density polyethylene barrier fence free of holes tears and other defects. Provide 4' tall fence in diamond or rectangular pattern. Fencing shall be "safety orange" color, unless otherwise noted.

B. Posts for temporary plastic barrier fencing shall be 5' tall, minimum 12 gauge, painted metal posts.

PART 3 - EXECUTION

3.1 MAINTENANCE OF SITE AND BUILDING ACCESS/EGRESS

A. Unless otherwise shown or directed, maintain existing access and egress to the facility throughout construction. Maintain ANSI A117 compliant access for disabled persons, delivery access, emergency vehicle access, and emergency egress. Do not interrupt access and egress without prior written approval from the Construction Representative.

3.2 CONTINUITY OF EXISTING TRAFFIC/PARKING AND TRAFFIC CONTROL

A. Do not interrupt or change existing traffic, delivery, or parking without prior written approval from the Construction Representative. When interruption is required, coordinate schedule with the Owner agency to minimize disruptions. When working in public right-of-way, obtain all necessary approvals and permits from the City of Madison.

B. When Contractor's activities impede or obstruct traffic flow, Contractor shall provide traffic control devices, signs and flaggers in accordance with other Contract Documents and the current version of the MUTCD, or as shown on the Drawings.

3.3 PROTECTION AND CONTINUITY OF EXISTING UTILITIES

A. Verify the locations of any water, drainage, gas, sewer, electric, drainage, gas, sewer, electric, telephone/communication, fuel, steam lines or other utilities and site features which may be encountered in any excavations or other sitework. All lines shall be properly underpinned and supported to avoid disruption of service.

B. Do not interrupt or change existing utilities without prior written approval from the Construction Representative, affected utilities and users. Notify all users impacted by outages a minimum of 48 hours in advance of outage. Notification shall be provided in writing and describe the nature and duration of outages and provide the name and number of Contractor's foreperson or other contact.

C. Any service connections encountered that are to be removed shall be cut off at the limits of the excavation and capped in accordance with the requirements of applicable codes and any specifications governing such removals.

3.4 PROTECTION OF EXISTING WORK AND FACILITIES

A. Verify the locations of, and protect, any signs, paved surfaces, buildings, structures, landscaping, streetlights, utilities, and all other such facilities that may be encountered or interfered with during the progress of the work. Take measures necessary to safeguard all existing work and facilities that are outside the limits of the work or items that are within the construction limits but are intended to remain. Report any damage to existing facilities to the Construction Representative immediately. Correct and pay for all damages.

3.5 CONSTRUCTION LAYOUT

A. Contractor shall establish all heights and grades to properly execute work from bench mark established by a surveyor (from original survey work). It is strongly recommended that the design engineering firm be contacted and used for all construction layout as well as as-built surveys in an effort to avoid conflict between datums and horizontal control points used. Prior to construction layout, existing and proposed finished floor elevations shall be checked with respect to current site benchmarks to ensure elevations correspond with layout elevations.

B. Contractor shall provide all construction layout surveys to accurately locate the construction on the site.

3.6 STORMWATER/EXCAVATION WATER MANAGEMENT

A. Control grading around structures, pitch ground to prevent water running into excavated areas.

B. Pits, trenches within building lines and other excavations shall be maintained free of water.

C. Provide trenching, pumping, other facilities required.

D. Notify Architect/Engineer if springs or running water are encountered in excavation; provide discharge by trenches, drains, pumping to point outside of excavation. Provide information to Architect/Engineer of points and areas that water will be discharged. At the Engineer's option, the Contractor shall drain the spring to the storm sewer system by the use of field tile.

E. Be responsible for control measures to prevent damage from flooding, erosion, and sedimentation to on-site and off-site areas.

END OF SECTION

SECTION 32 11 23.33
DENSE GRADED BASE

PART 1 - GENERAL

1.1 SCOPE

A. This section includes information common to dense graded base using crushed stone or crushed gravel and applies to all sections in this Division.

1.2 REFERENCE STANDARDS

A. Work under this section depends on applicable provisions from other sections and the plan set in this contract. Examples of related sections include, but are not limited to:

1. Division 31 — Earthwork

B. Wherever WisDOT or SSHSC appears in this specification it shall be construed to mean the pertinent sections of the State of Wisconsin, Department of Transportation, Standard Specifications for Highway and Structure Construction (SSHSC), current edition, and all supplemental and interim supplemental specifications, as they may pertain, except this contract shall be a lump sum contract and measurement and basis of payment methods shall not apply.

C. Dense Graded Base shall conform to City of Madison standard specification Article 401 – Crushed Aggregate Base Course.

1.3 SUBMITTALS

A. Provide copies of record drawings.

B. Provide copies of material testing reports.

C. Provide the following prior to construction:

1. Manufacturers product information (cut sheets)

2. Mix designs and specifications

3. Aggregate Gradations

D. Materials conforming to the WisDOT Standard Specifications for Highway and Structure Construction (Latest Edition, hereafter called “Standard Specifications for Highway Construction” and supplied from a WisDOT approved source need not be tested. The contractor shall furnish evidence of such WisDOT approval to the A/E and/or Construction Representative.

E. Maintain record drawings showing actual locations of utilities and other features encountered, modifications to proposed grades and site features, and other deviations from the original design.

PART 2 - PRODUCTS

2.1 GENERAL

A. Use dense graded base. Materials shall conform to Section 301.2 of the WisDOT Standard Specifications for Highway and Structure Construction. Material gradations shall conform to Section 305.2.2 of the WisDOT Standard Specifications for Highway and Structure Construction unless specified elsewhere in the contract documents.

B. Base Course Gradation: 1-1/4" Crushed Aggregate

C. Materials shall conform to Gradation No. 2 per the City of Madison specification 401.1(b).

2.2 BREAKER RUN AGGREGATE

A. Crushed stone, rock or gravel meeting the requirements of either Breaker Run or Select Crushed material as defined in Section 311.2 or Section 312.2 of Standard Specifications for Highway Construction, respectively.

PART 3 - EXECUTION

3.1 CONSTRUCTION

A. Preparing The Pavement Foundation (Sub-Grade):

1. Prepare the foundation, or resurface the previously placed base layer, as specified in WisDOT Section 211 before placing base. Do not place base foundations that are soft, spongy, or covered by ice or snow. Water and rework or re-compact dry foundations as necessary to ensure proper compaction, or as the representative designates.

    a. In proposed pavement areas, all organic solid shall be removed.

    b. Excavation shall be reasonably free of water prior to beginning filling. Do not place material on frozen surfaces or use frozen material.

    c. In areas of existing pavement to be modified or adjusted in grade, the existing pavement section shall be removed by an acceptable method. The new pavement section shall match the construction details.

    d. Place and compact material to minimize settlement and avoid damage to structures, pipes, utility lines and other features. Hand place and compact material as necessary.

    e. Moisture condition backfill material as necessary to achieve density required for given use.

    f. Compact fill material as required for the given use.

    g. It is the responsibility of the Contractor to provide all necessary compaction equipment and other grading equipment that may be required to obtain the specified density. Vibratory plate or tamping type walk behind compactors will be required whenever backfill is placed adjacent to structures, pipes, utility lines and other features.

    h. Where additional filling or excavation is necessary, or placement of base course will be delayed, roll surface of proposed roadway or parking lot with a smooth drum roller to provide relatively impervious surface and promote drainage.

2. Proof-roll all subgrade areas that are to receive aggregate base or pavement. Proof-roll with a loaded dump truck prior to the placement of base courses to locate soft spots that yield under loading. Overexcavate (undercut) areas of soft subgrade that will not compact readily when proof-rolled or tamped. Backfill with breaker run or select crushed material as approved by the project representative.

    a. Prior to undercutting or excavating below subgrade (EBS) or placing any base course, contact the Construction Representative to schedule inspection of subgrade and proof-rolling. Provide minimum of 24 hrs confirmed notice. All proof-rolling shall be completed in the presence of the Construction Representative and Geotechnical Consultant.

b. To complete proof-rolling, entire roadway subgrade shall be provided with a relatively smooth surface, suitable for observing soil reaction during proof-rolling.

c. Contractor shall schedule and provide a fully loaded tri-axle dump truck for proof-rolling. Loaded truck shall have a minimum gross operating weight of 30 tons. Test shall be conducted with “tag” or “pusher” axles retracted from the ground.

d. Test-rolling shall be accomplished in a series of traverses parallel to the centerline of the street or parking area. The truck shall traverse the length of the street or parking area once for each 12’ of width. Additional passes along the traverse shall be completed as directed by the Geotechnical Consultant, to further define unsatisfactory subgrade.

e. Soft areas, yielding areas, cracked areas or areas where rolling or wave action is observed shall be considered indicative of an unsatisfactory subgrade. Such areas shall be undercut as outlined in Section 31 05 00.

f. Once the subgrade has been proof-rolled and approved, protect the soils from becoming saturated, frozen, or adversely altered.

g. Contractor shall assume 15% of proposed paved areas may require undercutting. This work shall be included in base bid. Undercut as outlined in Section 31 05 00.

B. Stockpiling:

1. If continuous compliance with material specifications is questionable, the project representative may require the contractor to supply material from a stockpile of previously tested material. Maintain a sufficiently large stockpile to preclude the use of material not previously approved.

2. Build and maintain stockpiles using methods that minimize segregation and prevent contamination. If the contract specifies location, place stockpiles where specified. Clear and prepare stockpile areas to facilitate the recovery of the maximum amount of stockpiled material.

C. Constructing Base:

1. Place aggregate in a manner that minimizes hauling on the subgrade. Do not use vehicles or operations that damage the subgrade or in-place base. Deposit material in a manner that minimizes segregation.

2. Construct the base to the width and section the plans show. Shape and compact the base surface to within 0.04 feet (12 mm) of the plan elevation.

3. Ensure there is adequate moisture in the aggregate during placing, shaping, and compacting to prevent segregation and achieve adequate compaction.

4. Maintain the base until paving over it, or until the project representative accepts the work, if paving is not part of the contract. The contractor is not responsible for maintaining material placed on detours.

D. Standard Compaction: Compact the base until there is no appreciable displacement, either laterally or longitudinally, under the compaction equipment. Route hauling equipment uniformly over previously placed base. Compact each layer before placing a subsequent layer. If the material is too dry to readily attain the required compaction, add water as necessary to achieve compaction

E. Special Compaction: If the contract requires special compaction, compact each layer to 95 percent of maximum density, or more, before placing the subsequent layer. The geotechnical engineer will determine the maximum density according to AASHTO T 99 method C or D and in-place density according to AASHTO T 191.

F. Controlling Dust: Apply water or other engineer-approved dust control materials to control dust during construction and maintenance of the base and shoulders.

3.2 COMPACTION

A. Compact each base layer, including shoulder foreslopes, with equipment specified in WisDOT Section 301.3.1. Use standard compaction conforming to WisDOT Section 301.3.4.2. Final shaping of shoulder foreslopes does not require compaction.

B. Compacting 1 1/4-Inch Base and 3/4-Inch Base. If using a pneumatic roller, do not exceed a compacted thickness of 6 inches (150 mm) per layer. For the first layer placed over a loose sandy subgrade, the contractor may, with the geotechnical engineer's approval, increase the compacted layer thickness to 8 inches (200 mm). If using a vibratory roller, do not exceed a compacted thickness of 8 inches (200 mm) per layer.

C. Compacting 3-Inch Base: Compact with a vibratory or pneumatic roller. Do not exceed a compacted thickness of 9 inches (225 mm) per layer.

3.3 UNDERCUTTING/EXCAVATION BELOW SUBGRADE (EBS)

A. Undercutting/EBS shall be completed only when directed by the Geotechnical Consultant. The Contractor shall not be compensated for any unauthorized undercutting/EBS. Measure and document undercut areas and depths in consultation with Geotechnical Consultant. Work shall comply with Section 31 05 00. Contractor shall assume 15% of proposed paved areas may require undercutting. This work shall be included in base bid.

3.4 CLEANUP

A. After the project is completed, thoroughly clean up all debris that may have accumulated during the placement of dense graded base. Replace or repair as required, all surfaces and/or landscape features damaged or disturbed under this item of work.

END OF SECTION

SECTION 32 12 00
ASPHALTIC PAVEMENT

PART 1 - GENERAL

1.1 SCOPE

A. This section includes information common to bituminous concrete paving work as shown on the drawings and applies to all sections in this Division.

1.2 REFENCE STANDARDS

A. Work under this section depends on applicable provisions from other sections and the plan set in this contract. Examples of related sections include, but are not limited to:

1. Division 31 — Earthwork

B. City of Madison Standard Specifications for Public Works Construction.

C. Part 4, “Pavements” of the latest edition of the Standard Specifications for Highway and Structure Construction of the State of Wisconsin, Department of Transportation.

1. 3 SUBMITTALS

A. Results from the Freeze / Thaw Test (AASHTO T103) for quarried course aggregates used in the work produced from limestone/dolomite sources. The maximum percent loss for aggregates used in the work shall be four percent (4%).

B. Asphalt Pavement mix designs in accordance with the aforementioned Part 4 of the latest edition of the Standard Specifications for Highway and Structure Construction of the State of Wisconsin, Department of Transportation. The asphaltic materials used shall comply with the current City of Madison specification Article 402 Asphalt Construction.

1.4 QUALITY ASSURANCE

A. Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:

1. Tack Coat: Minimum surface temperature of 60°F.

2. Asphalt Base Course: Minimum surface temperature of 40°F and rising at time of placement.

3. Asphalt Surface Course: Minimum surface temperature of 60°F at time of placement.

B. Pavement Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 40°F for oil-based materials, and not exceeding 95° F.

C. The paving crew shall be under the supervision of an experienced supervisor who shall be on the project at all times, and who shall not operate equipment, such as paving machines or rollers, at any time during the paving operation. Under no circumstances shall the workers, or others, be allowed to walk across recently laid asphalt mixture behind the paving machine and ahead of the roller.

D. A mechanical vibratory plate compactor shall be available on the job site at all times during asphalt pavement placement and shall be used for compaction around access structures, catchbasins, water valves and other castings which appear in the paved areas. The mechanical vibratory plate compactor shall be equipped with a working water reservoir and shall be of sufficient size and capability to attain the compaction requirements of these specifications.

E. Asphalt mixtures intended for use on City projects will be tested by the City in order to determine aggregate gradations, asphalt content, air voids and VMA. Asphalt mixtures shall be tested per section 460.2.8 of the latest edition of the Standard Specifications for Highway and Structure Construction of the State of Wisconsin, Department of Transportation

PART 2 - PRODUCTS

2.1 MATERIALS

A. The materials intended for use in base, lower, and upper layer mixtures, tack and seal coats, surface treatments, and similar work, shall comply with the requirements of Part 4, "Pavements" of the latest edition of the Standard Specifications for Highway and Structure Construction of the State of Wisconsin, Department of Transportation.

B. The Contractor shall provide Asphalt Pavement mix designs in accordance with the aforementioned Part 4 of the latest edition of the Standard Specifications for Highway and Structure Construction of the State of Wisconsin, Department of Transportation. The asphaltic materials used shall comply with the current City of Madison specification Article 402 Asphalt Construction.

2.2 RECYCLED ASPHALTIC MATERIALS

A. The contractor may use recycled asphaltic materials from FRAP, RAP, and RAS in HMA mixtures. Stockpile recycled materials separately from virgin materials and list each as individual JMF components.

B. Control recycled materials used in HMA by evaluating the percent binder replacement, the ratio of recovered binder to the total binder. Conform to the following:

Maximum Allowable Percentage Binder Replacement		
Recycled Asphaltic Material	Lower Layers	Upper Layer
RAS if used alone	25	20
RAP and FRAP in any combination	40	25
RAS, RAP and FRAP in combination	35	25
When used in combination the RAS component cannot exceed 5 percent of the total weight of the aggregate blend.		

C. This work shall consist of the construction of a plant mixed recycled asphalt mixture furnished and placed all in accordance with Article 460 of the latest edition of the Standard Specifications for Highway and Structure Construction of the State of Wisconsin, Department of Transportation, except as listed below.

D. The City of Madison shall approve the sources of recycled asphalt material, including shingles.

2.3 ASPHALT TACK COAT

A. Unless otherwise specified in the contract, or directed by the Engineer, the types and grades of asphalt materials and rates of applications in gallons per square yard and shall be type MS-2, SS-1, SS-1h, CSS-1, or an approved modified emulsified asphalt.

B. For existing concrete or asphalt pavements, the rate of application shall be between 0.05 and 0.10 gallons per square yard.

PART 3 - EXECUTION

3.1 SPREADING AND FINISHING

A. Pave at a constant speed, according to the paver specifications and mixture, for uniform spreading and strike-off with a smooth, dense texture and no tearing or segregation. In any event, the speed of placing asphalt mixtures shall not exceed that which coincides with the average rate of delivery to the paver, so as to provide as nearly as possible continuous operation of the paver.

B. The roller shall pass over an unprotected end of freshly laid mixture only when the laying of the course is to be discontinued long enough to permit the mixture to become cooled. In the event of such discontinuance, the end of the course shall be treated as a transverse construction joint as specified below.

3.2 COMPACTION

A. Where the edges are not supported by a curb and gutter or similar structure, the outside edges of the lower and upper layers shall be sloped and pressed in place by means of a self-adjusting constant pressure edge plate held in proper position on the finishing machine. A string line shall be used as a guide for the finishing machine in order to maintain a uniform edge alignment. If any other method is used, it shall meet the approval of the Engineer. The edge of the pavement shall be sloped approximately one (1) inch from the vertical and no material shall extend beyond the limits of the base. Irregularities in alignment along the outside edges and along the longitudinal joints shall be corrected by adding or removing paving mixtures before the edges are rolled.

B. The mixture shall be spread sufficiently so that after compaction the finished surface shall be one-eighth (1/8) to one-fourth (1/4) inch above the edges of curbs, gutters, access structures and similar structures. Each roller, while the paving is under way, shall be kept as nearly as practicable in continuous operation and the speed shall at all times be slow enough to avoid undue displacement of the mixture. When pneumatic-tired rollers are used, they shall be operated continuously at a rate of speed which will not cause damage to the mat and which will provide the maximum number of coverages possible while the temperature of the mat is conducive to densification and surface sealing. Rollers shall be operated with the drive roll or wheels nearest the paver.

C. Each roller, while the paving is under way, shall be kept as nearly as practicable in continuous operation and the speed shall at all times be slow enough to avoid undue displacement of the mixture. When pneumatic-tired rollers are used, they shall be operated continuously at a rate of speed which will not cause damage to the mat and which will provide the maximum number of coverages possible while the temperature of the mat is conducive to densification and surface sealing. Rollers shall be operated with the drive roll or wheels nearest the paver.

Minimum Required Density		
Layer	Percent of Target Maximum Density	
	Mixture Type	
	E-0.3, E-1, E-3	E-10

Lower	91.5	92
Upper	91.5	92

3.3 JOINTS

A. Longitudinal joints including mainline interior joints for all pavement layers shall be "hot" joints. "Hot" joints will be defined as joints with a temperature at or above the asphalt mixture compaction temperature. The Contractor shall provide the compaction temperature as part of the mix design submittal.

B. Where reheating of joints is needed to create a "hot" joint, reheating equipment and methods shall be in accordance with the latest edition of the Standard Specifications for Highway and Structure Construction of the State of Wisconsin, Department of Transportation, specifically Reheating HMA Pavement Longitudinal Joints, Item 460.4100S.

C. Where "Michigan" joints are placed to allow traffic use, the joint shall be milled, reheated and tacked in accordance with the above stated reheating specification before continuation of paving.

D. Contractor's operations shall not result in additional transverse joints unless approved by the Engineer.

3.4 ASPHALT PAVEMENT

A. Unless otherwise specified or directed by the Engineer, asphalt driveways and asphalt terrace paving shall be constructed of three (3) inches of upper layer pavement installed in one (1) lift on select fill, or as directed by the Engineer. E-0.3 mixture with 9.5mm nominal aggregate size or an approved commercial mix shall be used, unless a substitute is approved by engineer.

B. The composition for the various asphalt mixtures shall conform to the limits specified in Part 4 of the latest edition of the Standard Specifications for Highway and Structure Construction of the State of Wisconsin, Department of Transportation. Warm mix HMA is not approved.

C. The mixture shall be laid and compacted so that the average yields in pounds per square yard shall conform to the following charts showing the various thicknesses of installation:

Upper & Lower Layer(s) Yield-#S.Y.		
Thickness	Min.	Max.
1.5"	172	180
1.75"	201	210
2"	230	240
2.5"	287	300

3”	345	360
4”	460	480
5”	575	600

D. Unless otherwise specified in the contract, or directed by the Engineer, the upper layer mixtures shall be installed in one course of one and one-half (1-3/4) inches in depth.

E. For installations of the upper layer which are specified to be other than one and one-half (1-1/2) inches in depth, the allowable yields for such installations shall be in proportion to the allowable yields specified above.

F. Whenever the yields fall below the minimum allowable yields specified above, the Engineer shall determine the corrective action to be taken. The corrective action may include removal and replacement of the area of deficient thickness, an overlay with approved material of the area of deficient thickness, or such other action as the Engineer shall determine. The area of deficient thickness shall be determined on the basis of project area or area covered in one day’s operation, whichever is less. The Engineer’s determination will be based on the circumstances of the area involved, and will include a determination of the distribution of costs of the corrective work required.

END OF SECTION

SECTION 32 13 00
CONCRETE WORK OUTSIDE THE BUILDING ENVELOPE

PART 1 - GENERAL

1.1 SCOPE

A. Work Included: Cast-in-place concrete required for this Work is indicated on the drawings and includes, but is not necessarily limited to:

PART 1 – General
- Scope
- Quality Assurance
- Submittals
- Product Handling
- Reference Specifications
- LEED Certification Requirements

PART 2 – Products
- Concrete Materials
- Miscellaneous Materials
- Mixes and Delivery
- Detectable Warning Field

PART 3 – Execution
- Field Quality Control
- Preparation
- Concrete Placement
- Concrete Joints
- Expansion/ Isolation Joints
- Concrete Curing and Protection
- Tolerances
- Dense Graded Base
- Concrete Curb and Gutter
- Concrete Sidewalks, Pads and Driveways
- Curb Ramps
- Miscellaneous Concrete and Cement Work

B. Provide all work, materials, labor, equipment and supervision necessary.

C. Related work described elsewhere:

Section 31 05 00	Common Work Results for Earthwork (Outside the Building Footprint)
Section 32 11 23.33	Dense Grade Base

1.2 QUALITY ASSURANCE

A. All work shall be in accordance with applicable manufacturer's and supplier's instructions.

B. Qualifications of Workers:

1. Provide at least one person who will be present at all times during execution of this portion of the work who is thoroughly trained and experienced in placing the types of concrete specified and who will direct all work performed under this Section.

2. For finishing of exposed surfaces of concrete, use only thoroughly trained and experienced concrete finishers.

3. Concrete field tests for water content, slump, air content, yield and strength cylinders shall be conducted by a certified Wisconsin Concrete Technician, or technician of equivalent certification.

C. Correction of Defective Work: All concrete work which does not conform to the requirements of the Contract Documents and ACI 301, including function, durability, appearance, strength, cracking, tolerances and finishing, shall be corrected as directed by Architect at Contractor's expense. Additional testing, engineering, reinforcement and removal and replacement of defective concrete shall be paid for by Concrete Contractor. Contractor shall also be responsible for the cost of corrections to any other work affected by or resulting from corrections to the concrete work.

1. Concrete repairs including, but not limited to, patching, epoxy injection, routing and sealing, shall be performed by a specialty repair/restoration contractor, certified by the material supplier.

a. Provide qualifications to Architect and Structural Engineer for review and approval.

b. Restoration contractor shall provide material lists, and describe means and methods to Architect and Structural Engineer for review, prior to commencement of work.

c. Acceptance of units, repaired pursuant to written approval, is contingent upon repairs being skillfully done so as to be sound, permanent, flush with adjacent surfaces and, when exposed, of color and texture matching similar adjoining surfaces and showing no apparent line of demarcation between original and repaired work.

1.3 SUBMITTALS

A. Materials List: Within 30 days after award of Contract, and before any concrete is delivered to the job site, submit to Architect, in accordance with General Conditions, a complete list of all materials proposed to be furnished and installed under this portion of the Work, showing manufacturer's name and catalog number of all items such as admixture and membrane, and the name and address of transit-mix concrete supplier. Prior to starting construction, General Contractor shall also furnish a statement to Architect giving source, sieve analysis and specific gravity of both fine and coarse aggregate, proportions by weight (dry) of cement, fine and coarse aggregates, admixtures, and water that will be used in the manufacture of each class of concrete specified. No change in source of materials shall be made without prior notification to Architect.

B. Concrete Mix Design: Submit Mix Design to Architect for review. This submittal shall include the following:

1. Required cylindrical compression strength for f'c (28 day).

2. Element (curb, driveway, etc.) in which each class (strength of concrete) will be used.

3. Cylinder compressive strength test results or complete standard deviation analysis in accordance with ACI 318 Section 5.3.

4. Proportions of Materials.

5. Source of materials - Cement (type and brand), gravel pit.

6. Aggregate size and certification from an independent testing lab that gradation, specific gravity, soundness, absorption, and impurities meet ASTM requirements.

7. Admixture brand, dosage, literature.

8. Air content.

9. Water content and target slump.

10. Range of ambient temperature and humidity for which design is valid.

11. Special characteristics of mix which require precautions in mixing, placing, or finishing techniques to achieve finished product specified.

C. Product Data: Submit manufacturer's product data for review with application and installation instructions for proprietary materials and items including: patching compounds, epoxies, curing compounds, dry-shake finish materials, hardeners, sealers etc. for all items specified and used in materials list.

D. Substitutes to Specified Items:

1. Provide all product literature for substitutes to Architect for review.

2. Manufacturer's Representative shall certify in writing that the proposed substitute product meets or exceeds all requirements, test results, etc. in the Specification and the specified product's literature. Provide test results performed by an independent testing agency using the same test methods.

3. Specify amount of credit to owner if substitute is approved.

E. Construction Joints: Submit drawing of proposed construction joints for review for slabs on grade if different from those shown on drawings or if none shown on drawings.

F. Transit-mix delivery slips: With each load of concrete delivered to job, there shall be furnished by ready-mixed concrete producer duplicate delivery tickets, one (1) for Contractor and one (1) for Owner's representative. Delivery tickets shall provide following information:

1. Date

2. Name of ready-mixed concrete plant

3. Job location

4. Contractor

5. Type (Standard, A.E. or H.E.S.) and brand name of cement

6. Class and specified cement content in pounds per cubic yard of concrete

7. Truck number

8. Time dispatched

9. Amount of concrete in load in cubic yards

10. Admixtures in concrete

11. Maximum size of aggregate

12. Water added at job, if any.

13. Make the record available to Architect for inspection upon request.

G. Provide samples of broomed finish, stamped patterns, and dye colors.

H. Provide copies of all quality assurance testing reports.

I. Provide manufacturers product information (cut sheets) for truncated domes.

J. Sample Color Samples for Architectural Concrete (if applicable)

1. Provide to Architect for review 18" x 18" x 2" samples of concrete made with cement from various manufacturers for color selection and to establish the "Design Reference Standard" per ACI 303.1. Each sample shall be marked with name of cement manufacturer and type of aggregate used. Provide one (1) screed finish and one (1) trowel finish sample of each type.Color as selected by Architect.

2. Before any forms are constructed for exterior or exposed architectural concrete, erect sample wall panel of size shown on drawings, or of size sufficient to show full range of finishes, showing both vertical board and smooth finish surfaces, and meeting the requirements of ACI 301 and 303.1. No work shall proceed until sample has been approved by Architect.

1.4 PRODUCT HANDLING

A. Protection: Use all means necessary to protect cast-in-place concrete materials before, during and after installation and to protect the installed work and materials of all other trades.

B. Replacements: In the event of damage, immediately make all repairs and replacements necessary to the approval of Architect at no additional cost to Owner.

C. Do not use aluminum pipe if concrete is to be transported by means of pumping. Aluminum will not be allowed in concrete.

1.5 REFERENCE SPECIFICATIONS

A. The following latest edition reference specifications, guides and standards shall become part of this specification as if herein written. If provisions conflict, the more stringent provisions shall apply.

ACI 117 - Specifications for Tolerances for Concrete Construction and Materials and Commentary.

ACI 211.1 - Recommended Practice for Selecting Proportions for Normal Mass and Heavyweight Concrete.

ACI 211.2 - Recommended Practice for Selecting Proportions for Lightweight Concrete.

ACI 212 - Chemical Admixtures for Concrete.

ACI 214 - Recommended Practice for Evaluation of Results of Tests used to Determine the Strength of Concrete.

ACI 302.1 - Guide for Concrete Floor and Slab Construction.

ACI 303.1 - Standard Specification for Cast-In-Place Architectural Concrete.

ACI 304 - Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete.

ACI 304.2R - Placing Concrete by Pumping Method

ACI 305.1 - Specification for Hot Weather Concreting ACI 306 - Cold Weather Concreting.

ACI 306.1 - Standard Specification for Cold Weather Concreting.

ACI 308.1 - Standard Specification for Curing Concrete.

ACI 309 - Recommended Practice for Consolidation of Concrete.

ACI 318 - Building Code Requirements for Reinforced Concrete.

ACI ITG-4.1 - Specification for High-Strength Concrete in Moderate to High Seismic Applications (IBC Seismic Design Categories C-F)

ASTM C 31 - Method of Making and Curing Concrete Specimens in the Field.

ASTM C 33 - Standard Specification for Concrete Aggregate.

ASTM C 39 - Test Method for Compressive Strength of Cylindrical Concrete Specimens.

ASTM C 94 Standard Specification for Ready-Mixed Concrete.

ASTM C 138 - Standard Method of Test for Weight per Cubic Foot, Yield, and Air Content (Gravimetric) of Concrete.

ASTM C 143 - Standard Method of Test for Slump of Portland Cement Concrete.

ASTM C 150 - Specification for Portland Cement. ASTM C 171 - Sheet Materials for Curing Compound. ASTM C 172 - Method of Sampling Fresh Concrete.

ASTM C 173 - Standard Method of Test for Air Content of Freshly Mixed Concrete by the Volumetric Method.

ASTM C 192 - Standard Method of Making and Curing Concrete Test Specimens in the Laboratory.

ASTM C 231 - Standard Method of Test for Air Content of Freshly Mixed Concrete by the Pressure Method.

ASTM C 260 - Specification for Air-Entraining Admixtures for Concrete.

ASTM C 330 - Standard Specification for Lightweight Aggregates for Structural Concrete

ASTM C 494 - Specification for Chemical Admixtures for Concrete.

ASTM C 595 - Specification for Blended Hydraulic Cements.

ASTM C 618 - Specification for Fly Ash and Raw or Calcinated Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.

ASTM C989 - Standard Specification For Slag Cement For Use in Concrete and Mortars.

ASTM C1017 - Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.

OSHA Standard "Safety and Health Regulations for Construction", Part 1926 Subpart Q: "Concrete and Masonry Construction."

ANSI A10.9 "Safety Requirements for Concrete Construction and Masonry Work."

Standard Specification for Highway and Structure Construction, State of Wisconsin.

AASHTO T 318 - "Standard Method of Test for Water Content of Freshly Mixed Concrete Using Microwave Oven Drying".

1.6 LEED CERTIFICATION REQUIREMENTS

A. Ready-mixed concrete including coarse and fine aggregate shall be supplied within a 500-mile radius of the Project site.

B. Liquid materials including sealers, hardeners, curing compounds, etc., shall be VOC-compliant (low-odor or zero- odor type).

C. LEED SUBMITTALS. Unless otherwise indicated, submit the following for each type of product provided under work of this Section:

1. Recycled Content: MR4

   a. Indicate recycled content; indicate percentage of pre-consumer and post-consumer recycled content per unit of product.

   b. Indicate relative dollar value of recycled content product to total dollar value of product included in project.

   c. If recycled content product is part of an assembly, indicate the percentage of recycled content product in the assembly by weight.

   d. If recycled content product is part of an assembly, indicate relative dollar value of recycled content product to total dollar value of assembly.

   e. If any fly ash, slag cement, silica fume, or other waste material is used in mix designs to replace Portland cement, submit the total volume of concrete cast in place and mix design(s) used showing the quantity of Portland cement replaced. Use LEED New Product Content Form.

2. Local/Regional Materials: MR5

   a. Sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.

   b. Manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.

   c. Product Value: Indicate dollar value of product containing local/regional materials; include materials cost only.

   d. Product Component(s) Value: Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.

3. Refer to Division 1 for additional requirements.

PART 2 - PRODUCTS

2.1 CONCRETE MATERIALS

A. General: Concrete shall conform to Sections 501 and 601 of the Standard Specifications for Highway Construction.

B. General: All concrete, unless otherwise specifically permitted by Architect, shall be transit-mixed in accordance with ASTM C 94.

1. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, each aggregate from one source, and each admixture from the same manufacturer.

2. In regions where Alkali Silica Reactions (ASR) occur concrete mixes shall be provided with proven performance history to mitigate the problems through the use of:

   a. Low-alkali cement

   b. Non-reactive aggregates

c. Pozzolans

d. Lithium-based admixtures

C. Portland Cement:

1. Standard Portland Cement: ASTM C 150, Type 1.

2. High Early Strength Portland Cement: ASTM C 150, Type 3.

3. Self-Consolidating Concrete (SCC): A highly flowable, non-segregating concrete that spreads into place, fills formwork, and encapsulates congested reinforcement, which can be placed by means of its own weight, with little or no vibration. The flowability of SCC is measured in terms of spread when using a modified version of the slump test (ASTM C143). The spread (slump flow) of SCC typically ranges from 18 to 32 inches and shall depend on the requirements for the project. The viscosity, as visually observed by the rate at which concrete spreads, shall be controlled when designing the mix to suit the type of application being constructed.

4. Mass Concrete: ASTM C 150, Type 2 or Type 5.

D. Aggregates:

1. In general, comply with ASTM C 33.

2. Fine natural sand, clean, hard, strong, durable, uncoated grains, free from all injurious, deleterious substances passing No. 4 sieve.

3. Coarse gravel or crushed stone, clean, hard, strong, durable, uncoated pieces free from deleterious substances.

a. 1-1/2" (3.8 cm) maximum size aggregate shall conform to gradation for size No. 4 and 3/4" (1.9 cm) aggregate to size No. 67 in Table II of ASTM C 33.

b. When 1-1/2" (3.8 cm) size is used, it shall be proportioned with 3/4" (1.9 cm) aggregate so as to produce gradation conforming to size No. 467 in Table II of ASTM C 33.

4. Where concrete is exposed to view, aggregate shall not contain iron or other staining elements.

5. For exterior exposed surfaces, sidewalks, drives, etc. and parking structures, do not use fine or coarse aggregates containing spalling-causing substances. The amount of chert with a specific gravity less than 2.40 shall be limited to 1.0% of the weight of the coarse aggregate.

E. In regions where Alkali Silica Reactions (ASR) occur concrete mixes shall be provided with proven performance history to mitigate the problems through the use of:

1. Low-alkali cement

2. Non-reactive aggregates

3. Pozzolans

4. Lithium-based admixtures

F. Fly Ash: ASTM C-618 Class "C", the product of only one manufacturer using one source of coal. Maximum loss of ignition shall not exceed three percent (3%). Use Class "F" Fly Ash for mass concrete. Use only when permitted by Engineer.

G. Slag Cement: ASTM C 989, Grade 100 or Grade 120 ground granulated blast-furnace slag.

H. Chemical Admixtures:

1. Admixtures shall not contain more chloride ions than are present in municipal drinking water.

2. Water Reducing Admixtures - conform to ASTM C 494, Type A

   a. "Eucon A+" (Euclid Chemical Co.)

   b. "Polyheed 997" (BASF)

   c. "WRDA with HYCOL" or "WRDA - 82" (W.R. Grace)

   d. "Catexol 1000N" (Axim)

   e. Approved equal

3. Water Reducing, Retarding Admixture - conform to ASTM C 494, Type D

   a. "Eucon Retarder - 75" or "Eucon DS" (Euclid Chemical Co.)

   b. "Pozzolith 100XR" (BASF)

   c. "Daratard - 17" (W.R. Grace)

   d. "Catexol 1000R" (Axim)

   e. Approved equal

4. High Range Water Reducing Admixture (Superplasticizer) - conform to ASTM C 494, Type F or G (retarding), site applied only.

   a. "Eucon 37/1037" or Plastol Series(Euclid Chemical Co.)

   b. "Rheobuild 1000" or "Glenium 3000 NS" (BASF)

   c. "Sikament" (Sika Chemical Corp.)

   d. "Daracem" or "ADVA" Series (W.R. Grace)

   e. "Catexol 1000SP-MN" (Axim)

   f. Approved equal

5. Mid-Range Water Reducing Admixture (MRWR) - conform to ASTM C 494, Type A.

   a. "Eucon MR", "Eucon X15" or "Plastol 341" (Euclid Chemical Co.)

   b. "Polyheed" or "Polyheed 997" (BASF)

   c. "Daracem" or "Mira" Series (W.R. Grace & Co.)

   d. Approved equal

6. Non-Corrosive, Non-Chloride Accelerator - conform to ASTM C 494, Type C or E. The admixture manufacturer shall provide long-term, non-corrosive test data from an independent testing laboratory (of at least 1 year duration) using an acceptable accelerated corrosion test method such as that using electrical potential measures.

a. "Accelguard 80, 90 or NCA" (Euclid Chemical)

b. "Polarset" (W.R. Grace)

c. "Pozzolith NC 534" or "Pozzutec 20+" (BASF)

d. "Catexol 2000RHE" (Axim)

e. Approved equal

7. Air Entraining Admixture - conform to ASTM C 260

a. "Air-mix" or "Air-mix 200" (Euclid Chemical Co.)

b. "Daravair" or "Darex" Series (W.R. Grace)

c. "MBAE 90" or "Micro-Air" (BASF)

d. "Catexol AE260" (Axim)

e. Approved equal

8. Viscosity Modifying Admixture for use in Self - Consolidating Concrete:

a. "Visctrol", (Euclid Chemical)

b. "V-mar3", (W.R. Grace)

c. "Rheomac VMA", (BASF)

d. "Sika Stabilizer 4", (Sika Corp.)

e. Approved equal

9. Prohibited Admixtures: Calcium chloride, thiocyanates or admixtures containing more than 0.05% chloride ions by weight of admixture are not permitted.

10. Certification: Written conformance to the above mentioned requirements and the chloride ion content of the admixture is required from the admixture manufacturer.

I. Synthetic Fibers shall be used in concrete mix design in lieu of welded wire fabric. Synthetic fibers shall not replace reinforcing rebar/dowels as depicted on the Construction Details.

1. For concrete sidewalks:

a. Matrix Bi-Blend micro fiber – FRC Industries. Application dosage shall be 1.5 pounds per cubic yard.

b. Approved equal

J. Evaporation retardant and finish aid:

1. "Confilm", BASF

2. "Eucobar", Euclid Chemical Co.

3. "Sealtight Evapre", W.R. Meadows, Inc.

4. Approval equal

K. Water: potable

L. Curing and Sealing Compound:

1. Curing and sealing compounds shall be used for interior or exterior applications where concrete is left exposed with no other finish coating or hardener. Compound shall be compatible with paint or striping applications.

2. Liquid type, membrane forming curing and sealing compound complying with ASTM 1315 Type 1, Class A with 25% solids, VOC compliant.

a. Provide test data from an independent testing laboratory indicating a maximum moisture loss of 0.04 grams per sq. cm. when applied at a coverage rate of 300 sq. ft. per gallon.

b. Colorless, clear or with fugitive dye or pigment, non-yellowing, U.V. resistant, resin based, not wax based.

1) "Sealtight Vocomp-25", W.R. Meadows, Inc. (Interior or exterior use - water base)

2) "Super Aqua Cure VOX", Euclid Chemical

3) "Super Diamond Clear VOX", Euclid Chemical

4) Approved equal

3. Provide a second application for sealing and dust- proofing after 30 days, unless noted otherwise.

M. Colored Concrete: Where colored concrete is specified by the Architect, provide integrally colored concrete with pure pigments containing no fillers or artificial adulterants. Colors shall meet standards of ASTM C979. Add to concrete in proportions recommended by manufacturer for type of concrete and installation. Color as selected by Architect.

1. Butterfield Color, Aurora, IL

2. Davis Colors, Beltsville, MD

3. Euclid Chemical Co., Cleveland, OH

4. Lambert Corp., Orlando, FL

5. Approved equal

2.2 MISCELLANEOUS MATERIALS

A. Expansion/Isolation Joints:

1. Premolded expansion joint strips 3/4” thick of premolded resilient, compressible, re-expanding, Non-extruding, bituminous and fiber materials, conforming to ASTM D 994.

2. Plastic joint fillers where called for on drawings or specified shall be foamed polyvinyl chloride plastic premolded joint filler, thickness and width as shown.

a. "Rodofoam, Grade 327" (Electrovert, Inc.)

b. Approved equal

3. Joint Filler and Sealants: Polyurethane joint sealant for slab-on-grade control and construction joints required for all exposed concrete including exterior construction.

a. "Sikaflex 2CSL" (Sika)

b. "THC-900", (Tremco), level surfaces

c. "Vulkem 245SL"

d. "THC-901", (Tremco), sloped surfaces

e. "Eucolastic II", (Euclid Chemical)

f. "Sonolastic SL2", (Sonneborn)

g. Approved equal

B. Felt: 15 lb. (6.8kg) asphalt saturated. ASTM D 250.

C. Edge Forms and Screeds: Proper wood or metal screeds, accurately leveled and securely fastened, shall be provided to bring the slabs to the required elevation for the concrete strike-off operation.

D. Moisture Absorptive Cover: Burlap cloth made from jute or kenaf, weighing approximately 9 oz. per sq. yd., complying with AASHTO M 182, Class 2.

E. Moisture Retaining Cover: One of the following, complying with ASTM C 171, for moist-curing concrete:

1. Waterproof Paper

2. Polyethylene sheet not less than 6 mills thick

3. Polyethylene-coated burlap

F. Bonding Compound: Polyvinyl acetate or acrylic base, re-wettable type, for cosmetic nonstructural repairs.

1. "Euco Weld" (Euclid Chemical)

2. "Weldcrete" (Larsen Co.)

G. Epoxy Products: Two component material suitable for use on dry or damp surface, complying with ASTM C 881, for use in all structural concrete repairs.

1. Products for Crack Repair:

a. "Eucopoxy Injection Resin" or "Dural 50"; Euclid

b. "Concresive Standard LVI"; BASF

c. "Product R303", Concrete Injection Resin; "Rescon" Technology Corp.

d. "Sikadur 35 Hi Mod LV"; Sika Chemical Company

e. Approved equal

2. Products for Epoxy Mortar Patches, Interior use:

a. "Concresive 3007" or "Concresive LPL Liquid"; BASF

b. "Euco Epoxy #452" or "Duralcrete System"; Euclid

c. "Product R616, Concrete Bonder" or "Product R404, Epoxy Mortar Resin"; Rescon Technology

d. "Sikadur 21 Lo Mod LV"; Sika Chemical Company

e. "Sikadur 23 Lo Mod Gel"; (overhead, vertical)

f. Approved equal

3. Products for Epoxying Bolts or Reinforcing Steel into Concrete:

a. "Euco 452 Gel" or "Euco 452MV" or "Duralcrete Gel"; Euclid

b. "Concresive 1420 Cartridge System"; BASF

c. "Product R606, Concrete Bonder"; Rescon Technology Corp.

d. "Sikadur 31 Hi-Mod Gel"; (vertical use) Sika Corporation

e. "Sikadur 32 Hi-Mod Gel"; (horizontal use) Sika Corporation

f. Approved equal

H. Polymer Modified Mortars for interior or exterior concrete surface repairs including spalls and patches in non- corrosive environments:

1. "Sika Repair 222 with Sikalatex R"; horizontal repairs; Sika Chemical Corp.

2. "Sika Repair 223 with Sikalatex R"; vertical repairs; Sika Chemical Corp.

3. "Euco Verticoat Supreme" or "Speed Crete Red Line"; Euclid Chemical

4. "Euco Thin Top Supreme" or "Tammspatch II"; Euclid Chemical

5. Approved equal

2.3 MIXES AND DELIVERY

A. Concrete Mix:

1. Ready-mixed concrete shall be subject to the following:

a. Concrete must meet all requirements of the ASTM C 94, ACI 211, ACI 318 Chapter 4 Durability Requirements, and those herein specified for materials, proportioning, mixing and other details of manufacturer, quality and deliver.

b. Submit suitable evidence as to experience, equipment and capacity of plant to Architect for approval.

B. Mix Proportioning: Furnish ready-mixed concrete in accordance with the following:

Type of Construction	Min. Comp. Strength at 28 day (U.N.O.) PSI	Max Slump In.	Max. Agg. In.	Min Cement Lbs/C.Y.	Air Entrained	Footnotes
Exterior Slab on Grade						
	4000	2-4	---	587	Yes	(1)(2)

FOOTNOTES:

(1) Air entrained concrete: Use for all exterior slabs, walls, walks, platforms, ramps, steps, all portions of parking ramps, and all other concrete exposed to freezing and thawing. Maximum water/cementitious ratio = 0.45.

(2) Minimum compressive strength at 3 days: 1800 psi. Maximum aggregate size shall not exceed one third of the slab on grade thickness. Coordinate with Contractor as to project schedule. Reduce water/cementitious ratio to 0.40, with MRWR or HRWR, to achieve required water vapor emission rates for installation of finish materials.

C. Additional Mix Requirements

1. Cement content specified above is minimum, except:

   a. If concrete mix test results in accordance with ACI 318 Section 5.3 indicate strength greater than that specified, reduction of specified cement content is allowed.

   b. Should test results indicate strength below that specified, additional cement shall be added without cost to Owner.

2. Fly Ash may be used as a pound for pound replacement of cement up to 20% of the total cementitious content, 25% for footings, except for finished flatwork during winter construction, subject to Architect's approval.

   a. Mixes shall develop sufficient strength to meet contractor's schedule for flatwork finishing and formwork removal. Adjust proportions of fly ash as required.

3. Combination of Fly Ash and Slag, at a 1:1 ratio, may be used as a pound-for-pound replacement of cement as follows:

   a. 30% of the total cementitious content, except for finished flatwork during winter construction.

   b. Mixes shall develop sufficient strength to meet contractor's schedule for flatwork finishing and formwork removal. Adjust proportions of fly ash and slag as required.

4. Air-Entrained Concrete:

   a. Concrete requiring air entrainment shall contain six (6) percent plus or minus one and a half (1.5) percent air by volume, (at end of discharge hose if pumped) for 3/4" dia. aggregate. Conform to ACI 318, Chapter 4. Give proper consideration to the reduction of air content when fly ash is used.

5. Where synthetic or steel fibers are used in slabs, mix designer shall adjust the admixture dosage and/or water content to maintain the specified slump and adjust mix for increase in air content from fibers.

D. Admixture Usage:

1. All concrete must contain the specified water-reducing admixture or water-reducing -retarding admixture and/ or the specified high-range water-reducing admixture (superplasticizer).

2. Specified cement contents shall be increased 10 percent (10%) when no water-reducing admixtures are used.

3. When temperature is at or below 40 degrees F when placing or within next 24 hours, all concrete, less than 8" in thickness, shall contain the specified non-corrosive, non-chloride accelerator.

4. All concrete required to be air entrained shall contain an approved air entraining admixture.

5. All pumped concrete, concrete for industrial slabs, synthetic fiber concrete, architectural concrete, self-consolidating concrete (SCC), concrete for wall pours exceeding 14 feet in height or with high rebar congestion which makes consolidation difficult (bars at 4" on center or less), concrete required to be watertight and concrete with a water/cementitious ratio below 0.41 shall contain the specified site applied high-range water-reducing admixture (Superplasticizer). Mid-range plasticizers may be substituted for high-range when water- cementitious ratios exceed 0.45. Do not use HRWR or MRWR at the batch plant.

6. When high temperatures and/or placing conditions dictate and/or when concrete temperatures exceed 80 degrees F. use a water-reducing- retarding admixture (Type D) in lieu of the water-reducing admixture (Type A).

7. Self-Consolidating Concrete (SCC) shall be used as noted on the plans. The concrete shall contain the specified high-range water-reducing admixture and viscosity-modifying admixture where required. Minimum slump/flow of 20"-30" is required by the successful test placement. The workability, pumpability, finishability, and setting time of the proposed mix design shall be verified with a successful test placement onsite.

8. Admixture Certifications must be submitted with the proposed mix design for review by the Architect.

9. No other admixtures will be permitted.

E. Measuring Materials: Cement, aggregates, water and admixtures shall be measured and combined strictly in accordance with ASTM Specification C 94.

F. Mixing and Delivery:

1. Ready-mixed concrete shall be mixed and delivered to point designated by means and standards set forth by ASTM Specification C 94.

2. Mixers and agitators may be examined by a representative of Owner for changes in conditions due to accumulation of hardened concrete or mortar or through wear of blades.

3. When concrete is mixed in a truck mixer loaded to its maximum rated capacity, number of revolutions of drums or blades at a mixing speed shall not be less than 70 or more than 100.

4. When a truck mixer or a truck agitator is used for transporting concrete, concrete shall be delivered to site of work, and discharge shall be completed within one and one-half (1-1/2) hours or before drum has revolved a total of 300 revolutions, whichever comes first, after introduction of mixing water to the cement and aggregates, or mixing of cement and aggregates, unless a longer time is specifically authorized by Architect. In hot weather, or under conditions contributing to quick stiffening of concrete, concrete delivery and discharge shall be completed within 45 minutes.

5. Water may be added on the job site in the presence of a testing laboratory representative, to bring the slump to the specified level, but not to exceed 1 gallon per cubic yard and prior to any superplasticizer use. For concrete with w/c less than 0.41 and for concrete exceeding 4,600 PSI strength, concrete supplier's representative and Engineer shall provide approval prior to addition of any water. Mixing time shall be appropriately increased with a minimum of twenty (20) revolutions of the drum. The maximum slump shall not be exceeded with the addition of water. Concrete with higher slumps will be rejected. Contractor may exceed specified slump only if a superplasticizer is used. Amount of water added on the jobsite shall be recorded on each delivery ticket and concrete test report. All slump tests shall be taken after all water has been added. Water shall not be added to the batch at any later time.

6. Drivers may not wash concrete trucks, or discharge water at any time into pump hoppers used for concrete pumping operation.

2.4 DETECTIBLE WARNING FIELD

A. Detectable warning fields to be Neenah Foundry Detectable Warning Fields (or approved equal), unpainted natural color and field-weathered prior to installation. The color shall be verified with the owner prior to ordering and installation.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. The individuals who sample and test concrete to determine if the concrete is being produced in accordance with this specification, and that slump, air content, temperature and cylinder tests are in conformance with this Specification shall have demonstrated a knowledge and ability to perform the necessary test procedures equivalent to the ACI Minimum Guidelines for Certification of Concrete Field Testing Technicians, Grade 1. A current certificate shall be presented upon request by Architect.

B. All preparing of specimens and testing shall be performed by an independent laboratory hired by the Owner. Test reports shall be sent to Architect with copies to Contractor and ready mixed concrete producer.

1. This Contractor shall cooperate in taking of test samples and shall make adjustments in mix based on results of tests as directed by Architect.

2. Technician shall have full knowledge of required specifications prior to performance of field tests. Any non-conformance to specification shall be reported by email or fax immediately to Structural Engineer prior to field placement of concrete.

C. Samples of concrete shall be obtained in accordance with ASTM Method C 172 and shall be transported to a place on site where cylinders can be made and stored without being disturbed during first 24 hours.

D. Slump tests shall be performed in accordance with ASTM C143. Make one slump test of the first truck of each mix, each day, one test for each compression test and other tests as often as required thereafter, whenever consistency changes.

1. For parking structures, slump tests shall be performed for each truck load for flatwork.

E. When air-entrained concrete is used, air content tests shall be made from the first truck of each mix, each day and when- ever test cylinders are made, in accordance with ASTM C 173 or ASTM C231. Test more often when required air contents are not achieved.

1. For pumped concrete, air content tests shall be performed at point of discharge in addition to at the truck; once at the beginning of each pour and whenever the pumping orientation is significantly altered. Air contents shall be adjusted at the batching point as required.

2. Air entraining admixture may be added at the jobsite when air content tests too low.

F. Concrete Temperature: Test hourly when air temperature is 40 Degrees F (4 Degrees C) and below, and when 80 Degrees F (27 Degrees C) and above; and each time a set of compression test specimens is made.

G. If measured slump, air content or concrete temperature falls outside limits specified, a check test shall be made immediately on another portion of same sample. In event of a second failure, concrete shall be considered to have failed to meet requirements of specifications and shall not be used in structure. Notify Architect immediately.

H. Cylinders for strength tests shall be made in accordance with ASTM Method C 31. During first 24 hours all laboratory test specimens shall be covered and kept at air temperatures between 60 and 80 degrees F. (16 and 27 C). At the end of 24 hours, specimens shall be carefully transported to testing laboratory where molds shall be removed and cylinders shall be cured in a moist condition of 65 to 75 degrees F. (18 to 24 C.) until time of test. Strength tests shall be made frequently at direction of Architect. In no case shall any given class of concrete be represented by less than five (5) tests for entire job.

I. A strength test for any class of concrete shall consist of standard cylinders made from a composite sample secured from a single load of concrete in accordance with ASTM C-172.

1. All concrete less than 6000 psi:

a. After 24 hours four cylinders shall be carefully transported to the testing laboratory for moist curing.

b. One laboratory cured cylinder shall be tested at 7 days and two laboratory cured cylinders to be tested at 28 days; retain one cylinder for later testing, if necessary.

J. Strength tests shall be made for each of the following conditions:

1. Each day's pour,

2. Each class of concrete,

3. Each change of supplies or source,

4. Each 150 cubic yards of concrete or fraction thereof

5. Each 5000 square feet of surface area for slabs or walls.

K. To conform to requirements of this Specification, the strength level shall be considered satisfactory so long as the average of all sets of three (3) consecutive strength test results equals or exceeds the specified f'c and no individual strength test result falls below the specified strength f'c by more than 500 psi. Architect shall be notified immediately of nonconformance.

L. A record shall be made by a representative of testing laboratory of delivery ticket number for particular batch of concrete tested and exact location in work at which each load represented by a strength test is deposited.

M. Additional field-cured cylinder tests, in-place cylinders, non-destructive testing, and/or maturity testing may be performed, at Contractor's option and expense, to determine early strength of concrete to facilitate form or shoring removal and shorten construction schedules.

N. If, in the opinion of Architect, concrete of poor quality has been placed, additional tests shall be made as directed. Concrete quality shall be based on visual inspection of the concrete and review and analysis of the cylinder strengths. Additional tests shall be at the expense of Contractor. Tests may be compression tests on cored cylinders obtained by the Testing Laboratory per ASTM C42 or load tests per ACI 318 or as recommended by the Testing Laboratory and directed by the Architect. All testing costs chargeable to

Contractor will be obtained from him by means of a credit change order to the Contract.

3.2 PREPARATION

A. Notification:

1. Notify Architect at least 48 hours in advance before pouring.

B. Preparation:

1. Before Placing Concrete:

a. Clean all mixing and transporting equipment.

b. Remove all ice, snow, dirt, chips and other debris from forms or place to receive concrete.

c. Flush and wet down forms thoroughly to close any cracks between boards.

d. Wet down subgrade with as much water as it will absorb readily. Remove standing water.

e. Do not place concrete in dry forms or on dry subgrade.

3.3 CONCRETE PLACEMENT

A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.

B. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete will be placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as indicated. Deposit concrete to avoid segregation.

1. Deposit concrete in horizontal layers of depth to not exceed formwork design pressures and in a manner to avoid inclined construction joints.

2. Place all concrete in accordance with ACI 304, ACI 304.2R and ACI 302 for slabs. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.

3. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.

4. Crane or dump bucket may be used to transport concrete where concrete cannot be delivered to forms directly from chutes, into forms, wheelbarrows or two (2) wheeled concrete carts.

5. Specified superplasticizers, or approved alternative admixtures, are required in the concrete mix if concrete pumping is used for placement.

6. Delivery carts or buggies and/or pumping equipment shall be kept on temporary runways built over floor systems. Runway supports shall not bear on reinforcing steel or fresh concrete.

7. Concreting operation shall not alter location of reinforcing bars. Extreme care by workmen is required. Do not drag or drop equipment, such as pumping hose on reinforcement.

8. In no case shall concrete be delivered or placed with a free fall exceeding 10 feet for concrete containing superplasticizer, 15 feet for self-consolidating concrete (SCC) or 5 feet for other concrete. Spreading of concrete with hoes and shovels for distance greater than 6'0" from delivery end of chutes, carts or buggies will not be permitted.

9. Consistency of concrete to be such that it will be:

   a. Uniform throughout with mortar clinging to coarse aggregate;

   b. Plastic enough that concrete will work readily into corners and angles of forms and around reinforcement without excessive puddling or spading and without segregation of material or collecting of free water on surface while transporting or placing;

   c. Of sufficient mortar content in mass to fill all voids, prevent harshness or honeycombing in the structure and uniform distribute coarse aggregate.

10. Concrete shall be deposited in such a manner as to secure most thorough consolidation. Vibration with an approved "spud" type internal vibrator with flexible shaft shall be used where possible. Vibrator shall not come in contact with reinforcing or forms. Use and type of vibrators shall conform to ACI 309.

C. Deposit and consolidate concrete for slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.

1. Consolidate concrete during placement operations so concrete is thoroughly worked around reinforcement and other embedded items and into corners.

2. Maintain reinforcement in position on chairs during concrete placement.

3. Screed slab surfaces with a straightedge and strike off to correct elevations.

4. Slope surfaces uniformly to drains where required.

5. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, before excess bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.

D. Concreting In Cold Weather:

1. Follow ACI 306 and 306.1 for mixing, placing and protection, and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.

   a. When temperature is at or below 40 degrees F. (4 C.) when placing or within next 24 hours.

   b. Temperature of all surfaces in contact with newly placed contact shall be a minimum of 37ºF and shall not be more than 10ºF higher than minimum concrete placement temperatures specified in ACI 306.

   c. Provide heated concrete material with temperature of concrete when placed as recommended by ACI guidelines.

   d. Only the specified non-corrosive non-chloride accelerator shall be used. Calcium chloride, thiocyanates or admixtures containing more than 0.05% chloride ions are not permitted.

   e. Do not place on frozen subgrades.

f. Do not place concrete when the air temperature does not exceed 10F during the day.

g. Provide adequate housing covering and heating for freshly placed concrete for a minimum period of 72 hours after placing; maintain temperatures above 55^{O}F. Do not allow carbon dioxide from heating units to contact freshly placed concrete surfaces for a minimum of 48 hours. Vent all heaters outside of any enclosure.

h. All slabs on grade shall be protected from the penetration of frost by use of heaters, insulation, backfill, enclosures or other means. This protection shall exist throughout the entire construction period. Architect may inspect the frost penetration during construction. If frost is within 6 inches of the bottom of any construction in place, the Contractor shall take immediate steps to insulate or heat to prevent further frost penetration.

i. If the protection provided by Contractor is inadequate and frost penetration extends beneath the bottom of the construction, this shall be a basis for rejecting that portion of the work. This rejected work shall be removed and properly replaced at the expense of Contractor.

2. Contractor's Responsibility: Repair or replace, in manner acceptable to Architect, all concrete work damaged due to water, snow, freezing, excessive heating and too rapid drying out.

E. Hot Weather Concreting:

1. Conditions warranting hot weather concreting practices are defined as any combination of high air temperature, low relative humidity and wind velocity tending to impair the quality of fresh or hardened concrete or otherwise result in abnormal properties. Place concrete, cure and protect in compliance with ACI 305, Hot Weather Concreting. Do not place concrete when the air temperature is expected to reach 90^{O} F or greater when placing or within next 24 hours.

2. Temperature of concrete when placed shall not be less than 50 degrees F nor exceed 85 degrees F. Control by:

a. Cooling aggregates;

b. Using cement with maximum temperature of 170 degrees F. (77c);

c. Using cold water or ice.

3. Sprinkle forms, subgrade and reinforcing with cool water prior to placing concrete. Keep buggies, chutes and other equipment shaded.

4. Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that the steel temperature will not exceed the ambient air temperature immediately before embedment in concrete.

5. Mixing, Placing and Protection:

a. Keep mixing to minimum requirement which will insure adequate quality.

b. Do not expose mixers to hot sun.

c. Use concrete promptly.

d. Provide fog spraying operation immediately following placement and prior to final curing.

e. Finish promptly.

f. Protect and cure properly.

g. Do not use retarding agents unless approved by Architect.

h. Maintain concrete temperature not less than 50 degrees F nor more than 90 degrees F for the first three days after placing. Protect from temperatures over 90 degrees F for the next five days.

6. When high temperatures and/or placing conditions dictate, use a water-reducing-retarding admixture (Type D) in lieu of the water-reducing admixture (Type A).

F. Evaporation Retardant/Finishing Aid: During rapid drying conditions (high concrete or ambient temperatures, low humidity, high winds, direct sunlight, etc.) apply a concrete evaporation retardant and finishing aid to minimize plastic cracking. The compound may be required to be applied one or more times during the finishing operation. The initial application is usually made after the strike-off operation.

1. Use is subject to approval of membrane or sealer manufacturer.

3.4 CONCRETE JOINTS

A. Use and location of expansion, contraction, control and construction joints as approved by Engineer or as shown on drawings. Construct joints true to line with faces perpendicular to surface plane of concrete.

3.5 EXPANSION/ISOLATION JOINTS AND CONTROL JOINTS

A. At joints between slabs on earth and vertical surfaces, including columns, piers and walls, provide premolded joint filler strips. Before placing concrete, set isolation joint material in designated areas. Top of joint material shall be level to 1/4" below finished surface of concrete. Provide adequate means to maintain proper positioning of joint material during concrete placement. The minimum depth of isolation joint material shall be equal to the smaller of the concrete slab thickness with which it comes in contact.

B. Control (contraction) joints shall be provided in all slabs on earth by means of 1/8" to 1/4" wide saw cuts to a depth of 1/4 slab thickness when using conventional saws, 1.25" for early entry cut saws, approximately 12'-0" o/c each way as directed by Architect or as shown on drawings/details. It is preferred that saw-cutting while concrete is "green" to minimize dust and provide for better quality control. Provide dust barriers during cutting operations. Vacuum/clean surfaces following cutting operations to reduce residual concrete dust.

C. Where joint compound is indicated for control and construction joints, install premolded expansion joint filler strips topped with tapered, dressed, oiled wood strip to form groove at least 1" (2.5 cm) deep unless shown otherwise. After concrete has set, per manufacturer's exact specification, remove strip, grind or sandblast surfaces, prime, and fill groove with specified elastomeric sealant.

1. Required at exposed concrete surfaces including slabs, exterior driveways, garages, and parking areas.

3.6 CONCRETE CURING AND PROTECTION

A. General:

1. Protect freshly placed concrete from premature drying and excessive cold or hot temperatures in conformance with ACI 301 and ACI 308. After placement and prior to finishing of slabs, contractor shall use evaporation retardants, fogging, windscreens, etc. to prevent plastic shrinkage cracking caused by excessive drying of the top surface. For surfaces floated and broomed, place curing compound immediately where allowed.

2. Start initial curing as soon as free water has disappeared from concrete surface after placing and finishing. Keep continuously moist for not less than 24 hours.

3. Begin final curing procedures immediately following initial curing and before concrete has dried. Continue final curing for at least 7 days in accordance with ACI procedures. Avoid rapid drying at end of final curing period.

B. Curing Methods: Perform curing of concrete by curing compound, curing and sealing compound, by moist curing, by moisture-retaining cover curing and by combinations thereof, as herein specified.

1. Provide moisture curing by following methods:

a. Keep concrete surface continuously wet by covering with water.

b. Continuous water-fog spray.

c. Cover concrete surface with specified burlap absorptive cover, thoroughly saturating cover with water and keeping continuously wet. Place absorptive cover to provide coverage of concrete surfaces and edges with 4" lap over adjacent absorptive covers.

2. Provide moisture-cover curing as follows: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width sides and ends lapped at least 3" and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

3. Provide curing compound or curing and sealing compound to slabs as follows:

a. Apply curing compound, per manufacturer's specification, to concrete slabs, including construction joints, after form removal as soon as final finishing operations are complete (within two hours). Apply uniformly in continuous operation by power-spray or roller in accordance with manufacturer's directions. Recoat areas subjected to rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period. Cover with moisture retaining cover for 48 hours.

b. Exterior slabs shall have fugitive dye or pigment.

c. Apply at dosage rates per Manufacturer's written recommendation.

3.7 TOLERANCES

A. The construction tolerances for cast-in-place concrete shall meet the requirements of ACI 117 and 347 and the special project tolerance requirements listed below. Where requirements conflict, the more stringent shall govern.

1. Linear and Vertical Lines (When Forms are Stripped):

a. Perimeter slab edges shall be within + or - 3/8" of established lines.

2. Elevations:

a. Top of slab at perimeter edge shall be within + or - 1/4" of established elevations.

3. Slab Thickness: - 1/4" maximum.

3.8 DENSE GRADED BASE

A. Dense Graded Base, required to bring to proper level, are specified in Section 32 11 23.33.

3.9 CONCRETE CURB AND GUTTER

A. Concrete work shall meet the requirements of Division 03.

B. Provide curb and gutter of type and dimensions shown on the drawings, or to match adjacent existing curb and gutter.

C. Trowel and broom the face surface of curb and gutter. Fill any honeycombed or void areas remaining on the back of curbs with mortar.

D. Concrete curb and gutter shall be placed in accordance with WisDOT Section 601 to the dimensions and shapes shown in the standard detail drawings. Where curb and gutter details are not provided, curb and gutter shape and dimensions shall match existing adjacent curb and gutter.

E. A minimum 4 inch thick layer of compacted dense graded base shall be provided beneath the full width and a minimum 6 inches behind all curb and gutter. At sections of the curb and gutter to be replaced, the existing base course may be reused provided it conforms to the above requirement and is placed over a stable subgrade. Prior to placement of concrete, the base shall be thoroughly compacted and moistened.

F. All curved curb and gutter shall form smooth curves and shall not be a series of chords. Radius forms shall be used for all curved curb and gutter where the radius of curvature is 100 feet or less.

G. Driveway openings in the curb line shall be staked by CONTRACTOR in the field. The details for concrete gutter sections through a driveway are shown in the standard detail drawings.

H. A 3/4-inch thick expansion joint filler shall be provided in accordance with Section 415 of the WisDOT Specifications, through the curb and gutter at:

1. The ends of radii on curved sections including intersection radii.

2. At storm sewer inlets (5 feet away from each side);

3. At a maximum interval of 100 feet.

I. Expansion joint filler shall extend through the entire thickness of concrete, be perpendicular to the surface and at right angles to the line of the curb and gutter, and be left 1/4-inch below the gutter line.

J. At equally spaced, nominal intervals of not less than 6 feet nor more than 15 feet, with 10 feet typical, a contraction joint shall be tooled to a depth of 1/5 of the total concrete thickness with a 1/4-inch radius jointer. The contraction joint shall be tooled at right angles to the line of the curb and gutter from the top back of curb to the gutter flag.

K. CONTRACTOR shall provide curb and gutter with the following steel reinforcement:

1. Provide two 20-foot No. 4 rebars centered on each utility crossing with 3-inch bottom clearance. One bar shall be positioned 3-inches from the gutter flag and one bar shall be poisoned 3-inches from the back of curb.

2. Provide two 5-foot No. 4 rebars centered on each storm sewer inlet casting having a minimum 4 inches of concrete between the casting and the finished pavement. Rebars shall be positioned 2 inches from the gutter flag. One rebar shall be positioned 2 inches from the top gutter surface. The other rebar shall be positioned 4 inches from the top gutter surface.

L. The location and type of joints in curb and gutter shall match joints in adjacent pavement whenever possible.

3.10 CONCRETE SIDEWALKS, PADS AND DRIVEWAYS

A. Provide concrete pavement having the thickness and reinforcement as shown on the drawings, or to match

adjacent existing pavement.

B. Concrete shall have a minimum 28 day compressive strength of 4000 psi with 4% to 7% air entrainment.

C. Tie bars should be placed at all construction joints parallel to traffic and consist of No. 4 reinforcing bars, 24 inches in length and 48 inches on center.

D. 3/4 inch diameter epoxy-coated smooth dowel bars should be at all control joints perpendicular to traffic. Dowel bars shall be 18 inches long and 12" on center.

E. Expansion joints shall be provided where pavement abuts fixed objects, such as buildings and light poles. Control joints shall be in accordance with American Concrete Institute (ACI) recommendations.

F. Concrete sidewalk and driveway shall be placed in accordance with WisDOT Section 602 to the dimensions and thicknesses shown in the standard detail drawings.

G. A minimum 5 inch thick layer of compacted dense graded base shall be provided beneath all new sidewalks and driveways, unless otherwise noted in the standard details. Where sidewalks and driveways are to be replaced, existing base material may be reused provided it conforms to the above requirement and is placed over a stable subgrade.

H. Sidewalks shall slope toward the roadway at 1/4-inch per foot except the transverse slope of sidewalks at a driveway or alley entrance shall match slope of driveway or alley, but shall not exceed 3/4-inch per foot, unless otherwise noted on the drawings or requested by the engineer.

I. Concrete sidewalk shall be segmented into 5-foot long rectangular blocks with tooled joints made at right angles to the centerline of the sidewalk. Sidewalk intended as a multi-use path shall be segmented with sawcut joints instead of tooled joints. Tooled edges and joints shall be rounded with an edging tool of 1/4-inch radius. Concrete driveways shall be segmented into uniform rectangular blocks with sawcut joints at a maximum spacing of 12 feet in each direction (or as recommended by ACI). Joint depth must extend at least 1.25" for early entry saws or 1/4 of slab thickness if a conventional saw is used.

J. A 3/4-inch thick expansion joint filler shall be provided in accordance with Section 415 of the WisDOT Specifications, through the sidewalk. Filler shall be placed at:

1. The ends of radii on curved sections including intersection radii.
2. interfaces of sidewalks and driveways.
3. interfaces of driveways and curbs.
4. interfaces of sidewalks and curbs.
5. interfaces of sidewalks at corners.
6. at box-outs for castings;
7. at 100-foot intervals in sidewalks.

K. Where an existing curb stop box will lie within a proposed sidewalk or driveway apron, CONTRACTOR shall install a frost-proof collar prior to CONTRACTOR pouring concrete.

L. The final floating shall be done with a wooden float. Before the concrete is given the final surface finish, the surface of the walk shall be checked with a ten-foot straightedge, and any areas which show a variation or departure from the testing edge of more than 1/4-inch shall be corrected by adding or removing concrete as necessary while the concrete is still plastic. Before the mortar has set, the surface shall be brushed or lightly broomed. Review finishes and patterns on architectural and landscape plans if applicable.

M. Cure immediately after final finishing.

N. Replace any existing sidewalks, curbs, drives etc. damaged during the construction process.

3.11 CURB RAMPS

A. Curb ramps shall have a maximum slope as indicated in details.

B. Each curb ramp shall be provided with a detectable warning field installed in fresh concrete of all sidewalk and multi- use trails at legal crosswalks, and as shown in the detail drawings. A detectable warning field shall not be installed in asphalt pavements. The detectable warning field shall be installed per manufacturer's recommendations.

3.12 MISCELLANEOUS CONCRETE AND CEMENT WORK

A. Flag Pole Base:

1. Construct concrete base and install foundation tube, all in accordance with flag pole manufacturer's instructions, detail drawings and shop drawings.

2. Consult and work in cooperation with Contractor furnishing flagpole.

B. Building sign monument as detailed.

END OF SECTION

SECTION 32 14 13.19
PERMEABLE ARTICULATING CONCRETE BLOCK (P-ACB)

PART 1 - GENERAL

1.1 Definitions

A. Contract Documents – the Contract Documents establish the rights and obligations of the parties and include the Agreement, Addenda (which pertain to the Contract Documents), CONTRACTOR's Bid (including documentation accompanying the Bid and any post Bid documentation submitted prior to the Notice of Award) when attached as an exhibit to the Agreement, the Notice to Proceed, the Bonds, the General conditions, the Supplementary Conditions, the Specifications and the Drawings as the same are more specifically identified in the Agreement, together with all Written Amendments, Change Orders, Work Change Directives, Field Orders, and ENGINEER's written interpretations and clarifications issued on or after the Effective Date of the Agreement. Approved Shop Drawings and the reports of subsurface and physical conditions are not Contract Documents. Only printed hard copies of the items listed in this paragraph are Contract Documents. Files in electronic media format, of text, data, graphics, and the like that may be furnished by OWNER to CONTRACTOR are not Contract Documents.

B. CONTRACTOR – The individual or entity with whom OWNER has entered into the Agreement.

C. Drawings – That part of the Contract Documents prepared or approved by the ENGINEER which graphically shows the scope, extent, and character of the Work to be performed by the CONTRACTOR. Shop Drawings and other CONTRACTOR submittals are not Drawings as so defined.

D. ENGINEER- The individual or entity named as such in the Agreement.

E. OWNER – The individual, entity, public body, or authority with whom the CONTRACTOR has entered into the Agreement and for whom the Work is to be performed.

F. Project – The total construction of which the Work to be performed under the Contract Documents may be the whole, or part as may be indicated elsewhere in the Contract Documents.

G. Resident Project Representative – The authorized representative of the ENGINEER who may be assigned to the Site or any part thereof.

H. Samples – Physical examples of materials, equipment, or workmanship that are representative of some portion of the Work and which establish the standards by which such portions of the Work will be judged.

I. Shop Drawings – All drawings, diagrams, illustrations, schedules, and other data or information which are specifically prepared or assembled for the CONTRACTOR and submitted by the CONTRACTOR to illustrate some portion of the Work.

J. Site – Lands or areas indicated in the Contract Documents as being furnished by the OWNER upon which the Work is to be performeed, including the rights-of-way and easements for access thereto, and such other lands furnished by OWNER which are designated for the use of the CONTRACTOR.

K. Specifications – That part of the Contract Documents consisting of written technical descriptions of materials, equipment, systems, standards, and workmanship applied to the Work and certain adminstrative details applicable there to.

L. Subcontractor – An individual or entity having a direct contract with CONTRACTOR or with any other Subcontractor for the performance of a part of the Work at the Site.

M. Supplier – A manufaturer, fabricator, supplier, distributor, material man, or vendor having a direct contract with CONTRACTOR or with any Subcontractor to furnish materials or equipment to be incorporated in the Work by the CONTRACTOR or Subcontractor.

N. Work- The entire completed construction of the various separately identifiable parts thereof required to be provided under the Contract Documents. Work includes and is the result of performing or providing all labor, services and documentation necessary to produce such construction and furnishing, installing, and incorporating all materials and equipment into such construction, as required by the Contract Documents.

1.2 Samples

A. A Natural Gray full-sized P-ACB can be supplied upon request. Alternate color samples can be supplied in 4" x 4" coupons.

B. A minimum of 3 lbs. samples of proposed subbase and/or base aggregate materials must be supplied to the engineer of record for approval in accordance with Aggregate Subbase listed in Part 3 below.

1. 3 Scope of Work

A. The CONTRACTOR shall furnish all labor, materials, equipment, and incidentals required and perform all operations in connection with the installation of the Permeable Articulating Concrete Block (P-ACB) in accordance with the lines, grades, design and dimensions shown on the Contract Drawings and as specified herein.

1.4 Submittal

A. The CONTRACTOR shall submit to the engineer all manufacturer's performance research results and calculations in support of the permeable articulating concrete blocks P-ACB system and geotextile proposed for use.

B. The CONTRACTOR shall furnish to the engineer all manufacturer's specifications, literature, and installation drawings of the P-ACB.

1.5 Preconstruction Conference

A. Within 2 weeks prior to the installation of the P-ACB, a conference attended by CONTRACTOR, ENGINEER, Supplier, and others as appropriate will be held to establish a working understanding among the parties as to the Work and to discuss the schedules, procedures for handling Shop Drawings and other submittals, processing Applications for Payment, and maintaining required records.

PART 2 PRODUCTS

2.1 GENERAL

A. Permeable Articulating Concrete Blocks (P-ACB) shall be premanufactured of individual concrete blocks with specific stormwater runoff and storage capacities. Blocks shall be hand-placed or mechanically installed with the use of a clamping or suction lifting device.

B. Individual blocks in the P-ACB shall be staggered, beveled, and interlocked for enhanced stability. The blocks shall be constructed of closed cell blocks with an arched storage chamber for additional stormwater runoff as shown on the contract drawings. Each row of blocks shall be laterally offset by one-half block width from the adjacent row so that any given block is interlocked to four other blocks (two in the row above and two in the row below). Six adjacent blocks shall also surround each block.

C. Each block shall incorporate interlocking surfaces that prevent lateral displacement of the blocks. The interlocking surfaces shall not protrude beyond the perimeter of the blocks to such an extent that they reduce the flexibility or articulating capability of the system. Backfilling of the joints between the P-ACB with rock chips or sand is not required and shall not be done or included in the Work.

D. **Infiltration Performance**: The P-ACB will only be accepted when accompanied by documented third party infiltration performance characteristics based on ASTM C1701/C1701M-09, or C1781. The infiltration rate

shall be no less than 1,000 inches per hour on an outdoor working surface, with typical base material utilized for the test.

E. **Structural Performance:** The design of the P-ACB shall be capable of supporting AASHTO H-25 and HS-25 truck loading. The blocks shall be analyzed as unreinforced concrete arches supporting a uniform truck tire load with impact per AASHTO standards. The subgrade soil, geosynthetic and base preperation for the P-ACB shall be properly designed by a Registered Professional Engineer and inspected by the ENGINEER or the Resident Project Representative during and following the installation of the Work.

2.2 Cellular Concrete Blocks

A. Materials

1. Cementitious Materials - Materials shall conform to the following applicable ASTM specifications:

2. Portland Cements - Specification C 150, for Portland Cement.

3. Blended Cements - Specification C 595, for Blended Hydraulic Cements.

4. Hydrated Lime Types - Specification C 207, for Hydrated Lime Types.

5. Pozzolans - Specifications C 618, for Fly Ash and Raw or Calcinated Natural Pozzolans for use in Portland Cement Concrete.

6. Aggregates shall conform to the following ASTM specifications. Normal Weight - Specification C 33, for Concrete Aggregates.

B. Visual Inspection

1. All units shall be sound and free of defects that would interfere with the proper placing of the unit or impair the strength or permanence of the construction. Surface cracks incidental to the usual methods of manufacture, or surface chipping resulting from customary methods of handling in shipment and delivery, shall not be deemed grounds for rejection. Cracks exceeding 0.25 inches in width and/or 1.0 inch in depth shall be deemed grounds for rejection.

C. Physical Requirements

1. At the time of delivery to the work site, the units shall conform to the physical requirements prescribed in Table 1, Physical Characteristics.

TABLE 1: PHYSICAL CHARACTERISTICS

Item	Description	Values
Dimensions	Length x Width x Height	12” x 12” x 5.65” (+/- 1/8”)
Compressive Strength	ASTM D-6684 / C-140	Avg. of Three: 4,000 psi min. Individual units: 3,500 psi min.
Block Weight		Arched Block: 45-50 lbs/sf Solid Block: 55-60 lbs/sf
Loading Capabilities	Truck Load Traffic Rating	AASHTO H-20, HS-20, HS-25
Joint Filler Between Blocks	Material Used	NONE Required

Percent Open Space		Surface: 7% Storage: 20%
Water Absorption (%) Density (lbs/cf)	ASTM D-6684 Table 1 / ASTM C-140	9.1% Avg. of Three, 11.7% Individual 130 Avg of Three, 125 Individual
Storage Capacity	Above Aggregate Within Arch	0.0833 cf/block
Post-Installation, Verified Surface Infiltration Rate	ASTM C1701/C1701M-09 ASTM C1781	Ave of three tests: 1,000 inches/hour/sf (MIN. 3 tests)

D. Sampling and Testing

1. The OWNER, ENGINEER or their authorized representative shall be accorded proper access to the manufacturer to inspect and obtain samples of the Permeable Articulating Concrete Blocks at the place of manufacture from lots ready for delivery.

E. Expense of Tests

1. Additional testing and associated costs, other than that provided by the manufacturer, shall be borne by the OWNER.

F. Manufacturer

1. The Permeable Articulating Concrete Blocks shall be PaveDrain® or pre-approved equal, as represented or distributed by:

LOCALY	NATIONAL
Hanes Geo Components	PaveDrain, LLC
PH. (608) 712-3839	PH. (888) 575-5339
scott.bordeau@hanescompanies.com	info@pavedrain.com
www.hanesgeo.com	www.pavedrain.com

2. *"Or-Equal" Items:* If in ENGINEER's sole discretion an item of material or equipment proposed by CONTRACTOR is functionally equal to that named and sufficiently similar so that no change in related Work will be required, it may be considered by ENGINEER as an "or-equal" item, in which case review and approval of the proposed item may, in ENGINEER's sole discretion, be accomplished without compliance with some or all of the requirements for approval of proposed substitute items. A proposed item of material or equipment will be considered functionally equal to an item so named if:

a. in the exercise of reasonable judgment ENGINEER determines that: (i) it is at least equal in quality, durability, appearance, strength, and design characteristics; (ii) it will reliably perform at least equally well the function imposed by the design concept of the completed Project as a functioning whole, and;

b. CONTRACTOR certifies that: (i) there is no increase in cost to the OWNER; and (ii) it will conform substantially, even with deviations, to the detailed requirements of the item named in the Contract Documents.

PART 3 - FOUNDATION PREPARATION AND BLOCK INSTALLATION

3.1 Foundation and Preparation

A. General. Areas on which permeable articulating concrete blocks are to be placed shall be constructed to the lines and grades shown on the Drawings and to the tolerances specified in the Contract Documents. Any proposed changes shall be reviewed and approved by the ENGINEER.

B. References. Standard Specifications for Highway Construction, State of Wisconsin Department of Transportation.

C. Subgrade. Unless required on the Drawings, compaction of underlying subgrade soil shall be avoided or minimized in order to encourage infiltration of stormwater. A Geotechnical Engineer should be consulted to determine the CBR values of the subgrade prior to the installation of the subbase materials and geotextile stabilizing fabrics and grids.

D. Geotextile Separator or Geogrid Stabilization. Monofilament or multifilament geotextile, that include Mirafi RS380i or its equivalent, or other geotextile material as shown on the Drawings shall be installed on the bottom and sides of the excavation to prevent in – situ soil contamination of the clean aggregate subbase. A geogrid may be required for sub base stabilization, but is not recommended on the sides of the aggregate sub base to separate the in-situ soils from the clean sub base aggregate.

E. Aggregate Subbase. If more than 6" of base aggregate is required, as shown on the Drawings, only the top 4-6" shall be AASHTO #57 aggregate; this is the leveling course directly beneath the P-ACB blocks. Additional aggregate depth shall consist of either AASHTO #2 or #3 or as shown on Drawings. All aggregate shall be clean, angular on all sides with no less than 90% fractured faces. Do not use rounded river gravel or fractured river gravel for any application.

ASTM No. 57 Base
Grading Requirements

Sieve Size	Percent Passing
37.5 mm (1 1/2 in.)	100
25 mm (1 in.)	95 to 100
12.5 mm (1/2 in.)	25 to 60
4.75 mm (No. 4)	0 to 10
2.36 mm (No. 8)	0 to 5

ASTM No. 2 Subbase
Grading Requirements

Sieve Size	Percent Passing
75 mm (3 in.)	100
63 mm (2 1/2 in.)	90 to 100
50 mm (2 in.)	35 to 70
37.5 mm (1 1/2 in.)	0 to 15
19 mm (3/4 in.)	0 to 5

F. Crushed Aggregate Base Course: Follow State Specifications

G. Compaction: Standard compaction.

1. 95 percent maximum density determined by Modified Proctor.

2. Allow ENGINEER to inspect prepared base course and to witness proof roll test by a fully loaded dump truck. Reconstruct where deflection is greater than ½ inch.

3. Allowable deviation from design grade: ½ inch.

4. The base course shall be firm and non-yielding, compacted until it does not creep or weave in front of the roller or compacting vehicle.

5. The aggregate bedding layer shall be compacted to a smooth plane surface to ensure intimate and positive contact is achieved between the legs of the permeable articulating concrete blocks and the compacted aggregate subbase layer and the Geogrid Separator.

6. AASHTO #2 or #3 subbase aggregate shall be compacted in 6-8" lifts with a roller-compactor. The AASHTO #57 aggregate leveling subbase shall be rolled and then compacted with a minimum 10,000 psi plate compactor in both the perpendicular and parallel directions in the area of coverage.The CONTRACTOR shall compact a 2" layer of the AASHTO #57 Aggregate into AASHTO #2 or #3 aggregate.

H. Geogrid Separator. Install Terratex RX1100, (or equal) geogrid separator shall be directly on top of the compacted leveling course. The geogrid seperator may be installed prior to the compaction of the leveling course. This will create a "snow shoe" effect and minimize damage from foot traffic prior to placement of the P-ACB.

I. Inspection. Immediately prior to placing the P-ACB the prepared area shall be inspected by the ENGINEER or Resident Project Representative, the OWNER's representative, and or by the manufacturer's representative. No blocks shall be placed thereon until that area has been approved by the ENGINEER.

3.2 Placement of Permeable Articulating Concrete Blocks

A. General. Permeable articulating concrete blocks shall be constructed within the specified lines and grades shown on the Drawings.

B. Placement. The P-ACB shall be placed on the geogrid separator so as to produce a smooth plane surface. No individual block within the plane of placed articulating concrete mats shall protrude more than one-quarter of an inch unless otherwise specified by the ENGINEER.

C. Consultation. The Supplier will provide design and construction advice during the design and installation phases of the project. The Supplier will not supervise, direct, control, or have authority over or be responsible for CONTRACTOR's means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or for any failure of CONTRACTOR to comply with Laws and Regulations applicable to the performance of the Work.

D. Finishing. The joints between the P-ACB shall not be backfilled with smaller aggregates or sand in order to function properly. The joints shall be left open. This includes following maintenance of the P-ACB. If the joints are filled with smaller aggregates or sand, the CONTRACTOR shall be responsible for the removal of the material and perform infiltration tests to assure that the P-ACB meets the minimum infiltration tests described in this specification.

E. Post Installation Certification. Upon completion of the P-ACB installation, the surface infiltration rate of the pavement shall be verified by ASTM C1701M-09 or ASTM C1781 to confirm the required infiltration rate of the pavement (per Table 1). If the system fails to perform as required in section Table 1 of this spec, it shall be removed and replaced at the supplier's cost.

3.3 Maintenance of Permeable Articulating Concrete Blocks

A. General. The maintainabilty of the permeable articulating concrete blocks shall be based on a maintenance study of at least 24 months conducted by an independent or third party representation.

1. The study shall include multiple pre and post testing documentations in multiple locations of infiltration rates according to ASTM C1701 or a modified version of ASTM C1701 where the infiltration rate is recorded without a head pressure.

2. Subsurface aggregate performance of pre and post testing shall also be documented over a 24 month period.

3. The study shall show that following proper maintenance the original performance of the P-ACB can effectively be restored to at least 90% of its original performance.

B. Inspection & Maintenance. The manufacturer's representative of the P-ACB shall provide a minimum 36 month maintenance program; including a visual inspection report with photos and a recommended

cleaning schedule with a Vacuum truck such as the Elgin® Whirlwind® or Megawind® or with the PaveDrain® Vac Head and associated combination sanitation vac truck. The visual inspection and recommended cleaning schedule shall be included with the price of the system.

1. Maintenance utilizing a combination sanitation vaccum truck with the PaveDrain vac head will be quoted and supplied by others based on the maintenance program.

2. Maintenance shall be required when either of the following are reached:

   a. The surface infiltration rates of more than 75% of the surface area fall below 10% of the rate required in Table 1.

   b. Surface ponding remains for 24 hours in an area larger than 10 square feet.

END OF SECTION

SECTION 32 16 13
CONCRETE CURB AND GUTTER

PART 1 - GENERAL

1.1 SCOPE

A. This section includes information common to concrete curb and gutter and applies to all sections in this Division.

B. This work shall consist of constructing concrete curb and gutter, with or without reinforcement, of the dimensions and design as indicated, and placed in one course on the prepared foundation or base, at the locations and to the required lines and grades.

C. The Contractor shall mark the top of the curb where the sanitary sewer and water service cross the curb and gutter. The mark may be made by sawcutting. The depth shall be a minimum of one-sixteenth (1/16") inch deep. The laterals and services will be located by the City.

D. All work done in the vicinity of any tree located in the terrace shall be completed in accordance with City of Madison Standard Specifications for Public Works Construction Section 107.13 Tree Protection.

1.2 REFERENCE STANDARDS

A. Work under this section depends on applicable provisions from other sections and the plan set in this contract. Examples of related sections include, but are not limited to:

1. Division 03 — Concrete
2. Division 31 — Earthwork
3. 32 13 00 - Concrete Work Outside The Building Envelope

B. City of Madison Standard Specifications for Public Works Construction

PART 2 - EXECUTION

2.1 PREPARATION OF FOUNDATION

A. The Contractor shall be responsible for replacement with 1-1/2" crushed stone, mechanically compacted, of any material necessary to bring the subbase to grade, where the Contractor has undercut the subbase without the direction of the Engineer.

2.2 FORMS

A. Curb and gutter forms shall be of steel construction and conform to the design of the type of curb and gutter being installed. Wooden forms may be used only with the Engineer's approval on short radius curves and in special cases where accessibility is limited. All forms shall be free of hardened concrete, mud, dirt, and debris, and shall be free of bends and twists which would make their use unacceptable on the project.

B. All forms shall be oiled to the satisfaction of the Engineer before depositing or placing concrete in them.

C. When concrete curb and gutter is constructed on a curve, flexible forms shall be used for all curves having a radius of two hundred (200) linear feet or less.

2.3 PLACING AND FINISHING CONCRETE

A. Wherever directed by the Engineer, driveway gutters shall be built instead of regular curb and gutters.

B. The curb and gutter over ditches shall be installed in twenty (20) foot lengths centered over the ditch. A dummy joint shall be cut at the center of the 20 foot section.

C. Unless otherwise specified, curb and gutter shall be installed in minimum lengths of six (6) feet and maximum lengths of 15 feet.

D. The Contractor shall install a header at the end of each pour. At no time shall the Contractor be allowed to spread excess concrete as a base for the next or any succeeding pour.

E. Wherever different types of curb and gutter are employed, the Contractor shall take care that transitions from one type of curb and gutter to another type are done smoothly without loss of flow line grade or curb head shape.

F. The reconnection of existing drains from adjacent properties to the curb and gutter shall be incidental to concrete curb and gutter.

G. The slope of the curb and gutter shall not exceed 1” in 12” thru handicap accessible ramps.

2.4 JOINTS

A. Full contraction joints shall be a minimum of three (3) inches in depth, and shall be uniformly spaced not less than six (6) feet nor more than fifteen (15) feet apart unless otherwise directed by the Engineer.

B. If machine methods are used for forming and finishing curb and gutter the Contractor may saw contraction joints or planes of weakness may be created by the insertion of approved partial depth separator plates having a minimum depth of three (3) inches. The depth of cut and equipment used in sawing shall meet the approval of the Engineer. The sawing shall be done as soon as practicable after the concrete has set sufficiently to preclude raveling during the sawing and before any shrinkage cracking takes place in the concrete. If this method results in random cracking the Contractor shall be required to use the partial depth separator plates.

C. Transverse expansion joints shall be one-half (1/2) inch in width and shall be placed across the curb and gutter perpendicular to the curb line at all radius points of curves having a radius of two hundred (200) feet or less, and on both sides of all inlets installed in curb and gutter. All expansion joints shall extend through the entire thickness of the curb and gutter and shall be perpendicular to the surface. All expansion joints shall be formed by inserting during construction, and leaving in place, the required thickness of joint filler which shall extend through the entire thickness of both curb and gutter.

D. Where curb and gutter and concrete sidewalk or concrete driveways join, an expansion joint one (1) inch in width must be constructed between walks and curb.

E. The joint filler in transverse joints shall be flush with the finished surface of the gutter. The concrete adjacent to these joints shall be finished with a wooden float which is divided through the center and which will permit finishing on both sides of the filler at the same time. Before the curb and gutter is opened to traffic, excess joint filler shall be cut off level with the finished surface.

2.5 REINFORCEMENT

A. Where reinforcement is required it shall conform to and be placed in accordance with the Standard Detail Drawings, details shown on the plans, as specified in the contract, or as directed by the Engineer.

B. Where directed by the Engineer, the Contractor shall install three (3) one-half (1/2) inch round reinforcing rods fifteen (15) feet long in concrete curbs and gutters which span ditches.

2.6 PROTECTION

A. The curb and gutter must be protected from injury by traffic or other causes, and also from the rays of the sun until completely set.

B. In the event that concrete sidewalk, drives or curb and gutter are placed in cold weather, “Cold Weather Protection” shall be applied in accordance with The City of Madison Standard Specifications, Section 301.8(a) “Cold Weather Protection.”

2.7 HAND FORMED CURB AND GUTTER

A. The work under this item shall consist of manually forming and pouring curb and gutter at tight locations or where other structures prevent the use of a curb machine, as designated by the Engineer.

END OF SECTION

SECTION 32 17 23
PAVEMENT MARKINGS

PART 1 - GENERAL

1.1 SCOPE

A. The work under this section consists of providing all work, materials, labor, equipment, and supervision necessary to provide and install pavement markings as provided for in these specifications and on the drawings.

1.2 RELATED WORK

A. Applicable provisions of Division 01 govern work under this Section.

B. Related Work Specified Elsewhere:

1. Section 30 05 00 – Common Work Results For All Exterior Improvements

1.3 SUBMITTALS

A. Submit the manufacturer specifications for each pavement marking. The submittal for each material shall include the following at a minimum:

1. Pavement Marking Material and Manufacturer
2. Color and Batch Number
3. Date Manufactured (Material more than one year old will not be accepted)
4. Manufacturer Name and Address

PART 2 - MATERIALS

2.1 PAVEMENT MARKINGS

A. Furnish paint pavement markings conforming to WisDOT Section 646.2 as specified in the drawings.

B. Paint markings shall be the color yellow for all pavement markings.

PART 3 - EXECUTION

3.1 PAVEMENT MARKINGS

A. Preparing The Pavement Foundation (Sub-Grade):

1. Prepare surface to receive markings and install them in accordance with WisDOT Section 646.3.
2. Apply pavement markings at the locations and to the dimensions and colors as shown on the drawings. If not otherwise specified, marking lines shall be yellow and have a minimum width of 4 inches.

3. Apply pavement markings at a rate per the manufacturers recommended application rate based on the temperature and surface material.

END OF SECTION

SECTION 32 91 13.50
STORMWATER BIOINFILTRATION

PART 1 - GENERAL

1.1 SCOPE

A. The work under this section shall consist of providing all work, materials, labor, equipment and supervision necessary to construct Stormwater Bioinfiltration Devices. The work under this section does not include providing all work, materials, labor, equipment, and supervision necessary to install plantings for the Stormwater Bioinfiltration Device.

1.2 RELATED WORK

A. Applicable provisions of Division 1 govern work under this Section.

1. Section 32 05 00 – Common Work Results For All Exterior Improvements
2. Section 31 25 00 – Erosion Control
3. Section 33 40 00 – Storm Drainage Utilities
4. Section 32 93 00 – Exterior Plants

1.3 REFERENCE STANDARDS

A.	WISDOT PAL	Wisconsin Erosion Control Product Acceptability List (PAL)
B.	WISDOT SSHSC	Standard Specifications for Highway and Structure Construction
C.	WI DNR	Standard 1002 – Site Evaluation for Stormwater Infiltration
D.	WI DNR	Standard 1004 – Bioretention for Infiltration
E.	WI DNR	S100 – Specification for Compost

1.4 SUBMITTALS

A. Provide product data for the following materials:

1. Geotextile Fabrics
2. Pipe
3. Aggregates
4. Sand
5. Compost
6. Engineered Soil
7. Erosion Mat

B. Provide product data for engineered soil blend components: Sand and Compost in compliance with WI DNR Standard 1004 – Bioretention for Infiltration for review and approval by DFD Project Representative.

1.5 QUALITY ASSURANCE

A. Contractor shall submit, in writing to the City Project Representative, a certification from compost supplier that any compost used on the project is in compliance with the requirements outlined in WDNR Specifications S100.

B. Contractor shall submit, in writing to the City Project Representative, a certification from engineered soil supplier that any engineered soil used on the project is in compliance with the requirements outlined in WI DNR Standard 1004 Bioretention for Infiltration.

PART 2 - MATERIALS

2.1 GEOTEXTILE FABRIC

A. Pipe Sock: The openings of the geotextile fabric shall be small enough to prevent sand particles from entering the underdrain pipe. The fabric shall meet the requirements of the WisDOT SSSHC Section 612.2.8.

B. Filter Fabric: The fabric shall meet the requirements of the WisDOT SSSHC Section 645.2.4, Geotextile Fabric Type DF, Schedule B.

2.2 PIPE

A. Underdrain Pipe

1. Pipe shall be corrugated HDPE or PVC, Schedule 40.
2. Pipe shall have a minimum diameter of 6-inches.
3. Pipe shall have perforations.
4. The pipe shall be covered with a filter sock if the storage layer is sand. The filter sock shall conform to the material requirement for Geotextile Fabric.

B. Cleanout Pipe: The cleanout pipe shall be rigid, non-perforated PVC covered with a watertight cap.

2.3 AGGREGATES

A. All aggregates used in the construction of Stormwater Bioinfiltration devices shall be double washed and free of organic material and fines.

B. Storage Layer Aggregate: The aggregate used for the storage layer shall meet the following gradation requirements:

Sieve Size	Percent Passing by Weight
2-inch	100
1 ½-inch	90-100
1-inch	20-55
3/4 –inch	0-15
3/8 – inch	0-5

C. Clear Stone Bedding: Washed angular stone or pea gravel shall be used to cover the underdrain pipe. Washed angular stone or pea gravel, graded from 3/8” to 1/4”.

2.4 SAND

A. The preferred sand component consists of mostly SiO_2, but sand consisting of dolomite or calcium may be used.

B. Manufactured sand or stone dust is not allowed.

C. The sand shall be washed and drained to remove clay and silt particles prior to mixing.

D. Sand shall meet one of the following gradation requirements:

1. USDA Coarse Sand (0.02-0.04 inches)

2. ASTM C33 (Fine Aggregate Concrete Sand)

3. WisDOT SSHSC Section 501.2.5.3.4 (Fine Aggregate Sand)

2.5 COMPOST

A. Compost shall meet the requirements of WI DNR Specification S100 – Compost.

2.6 ENGINEERED SOIL

A. Engineered Soil shall comply with WI DNR Standard 1004. Engineered Soil hall be a blend of Sand and Compost

B. Engineered Soil shall consist of a mixture of 70 to 85% Sand and 15 to 30% Compost. The percentages are based on volume.

C. Engineered soil mix shall be free of rocks, stumps, roots, brush or other material over 1 inch in diameter. No other materials shall be mixed with the planting soil that may be harmful to plant growth or prove a hindrance to planting or maintenance.

D. Engineered soil mix shall have a pH between 5.5 and 8.0.

E. Do not fertilize.

F. Thoroughly blend engineered soil off-site before delivering to site and installing.

G. Engineered soil shall be delivered to the site and stored on plastic sheeting.

H. The moisture content shall be low enough to prevent clumping and compaction during placement.

2.7 EROSION MAT

A. Erosion Mat shall comply with the PAL for Urban, Class 1, Type B as defined by Standard Specifications for Highway and Structure Construction and the PAL. Erosion mat shall be American Excelsior-Curlex Net-Free, Erosion Control Blanket-S32BD, Western Excelsior-Excel SS-2 All Natural, Ero-Guard EG-25 (NN), Erosion Tech ETRS2BN or approved equal.

PART 3 - EXECUTION

3.1 PROTECTION MEASURES

A. Pre-Installation Meeting: Prior to the installation of the Stormwater Bioinfiltration Device, the A/E, the City Project Representative, and the Contractor shall conduct a pre-installation meeting.

B. Stabilization: Construction of the Stormwater Bioinfiltration Device shall not begin until after the contributing drainage area has been stabilized with vegetation and/or hardscapes. Construction site runoff from disturbed areas shall not be allowed to enter the Stormwater Bioinfiltration Device.

C. Weather

1. Construction shall be suspended during periods of rainfall or snowmelt. Construction shall remain suspended of ponded water is present or if residual soil moisture contributes significantly to the potential for soil smearing, clumping, or other forms of compaction.

2. Delays resultant from weather shall not serve as a basis for a Change Order.

D. Compaction Avoidance

1. Compaction and smearing of the soils beneath the floor and side slopes of the Stormwater Bioinfiltration area, and compaction of the soils used for backfill shall be minimized.

2. During construction, the area dedicated to the Stormwater Bioinfiltration Device shall be cordoned off to prevent access by heavy equipment.

3. Acceptable equipment for constructing the Stormwater Bioinfiltration Device includes excavation hoes, light equipment with turf type tires, marsh equipment, or wide-track loaders.

E. Compaction Remediation

1. If compaction occurs at the base of the Stormwater Bioinfiltration Device, the soil shall be refractured to a depth of at least 24-inches.

2. If smearing occurs, the smeared areas shall be corrected by raking or roto-tilling.

3. Compaction and smearing remediation shall be conducted by the Contractor at no additional costs to the Owner.

F. Field Infiltration Testing

1. Immediately after rough grading of Stormwater Bioinfiltration Devices, provide field infiltration testing conducted by a third-party testing agency to verify infiltration rates for all Stormwater Bioinfiltration Devices. Field tests shall be conducted using a Double-Ring Infiltrometer per ASTM D3385. Calculate infiltration rates in accordance with Wisconsin Department of Natural Resources (WDNR) Site Evaluation for Stormwater Infiltration, Standard 1002. Frequency of testing shall be 1 test per 5000 square feet of surface area of the Stormwater Infiltration Device measured at the design high water level and at least one test per device. Furnish a report of the test results to Architect/Engineer.

3.2 TEMPORARY EROSION AND SEDIMENT CONTROLS

A. The Contractor shall install temporary erosion and sediment controls prior to beginning construction of the Stormwater Bioinfiltration Device. The temporary erosion and sediment controls shall divert stormwater runoff away from the Stormwater Bioinfiltration Device until it is completed.

3.3 Excavation

A. Excavation equipment shall work from the sides of the Stormwater Bioinfiltration Device to excavate the area to the depths and dimensions as shown on the Drawings. Excavation equipment shall have adequate reach so that they do not need to be located within the footprint of the Stormwater Bioinfiltration Device to excavate it.

B. Any accidental compaction shall be remediated as prescribed above.

3.4 STORAGE LAYER

A. Place the Storage Layer Aggregate to the depth as indicated in the Drawings.

3.5 UNDERDRAIN PIPE

A. Install underdrain pipe at the invert elevations indicated in the Drawings. Pipe shall be installed with a minimum slope of 0.005 ft/ft. Pipe joints shall be made in accordance with the manufacturer's recommendation. Standard pipe fittings shall be used.

B. Install cleanouts where shown. Cleanouts shall be installed with a watertight cap located flush with the surface of the Stormwater Bioinfiltration Device.

C. Connect pipe to drainage structure as indicated in the Drawings.

3.6 CLEAR STONE BEDDING

A. Clear Stone Bedding above the underdrain pipe to a thickness indicated in the Drawings.

B. Clear Stone Bedding layer shall be installed between the Storage Layer Aggregate and the Engineered Soil.

3.7 FILTER FABRIC

A. Install filter fabric around engineered soil extents including sides and bottom to separate from Engineered Soil and Storage Layer as shown in the Construction Drawings, overlapping edges a minimum of 6".

3.8 ENGINEERED SOIL

A. Verify moisture condition of Engineered Soil is low enough to prevent clumping and compaction during placement. Engineered Soil shall not be placed unless it meets these conditions.

B. Place Engineered Soil in lifts not to exceed 12 inches in depth until the desired elevation of the Stormwater Bioinfiltration Device is achieved.

C. Re-examine the surface within 48 to 72 hours following placement of Engineered Soil. Place additional Engineered Soil until desired elevation of the Stormwater Bioinfiltration Device is achieved at no additional costs to the Owner.

D. Steps may be taken to induce mild settling of the Engineered Soil as needed to prepare a stable planting medium and to stabilize the ponding depth.

E. Vibrating plate style compactors shall not be used to induce settling.

F. No equipment travel on or across placed Engineered Soil is permitted.

G. Install silt fence or other means of erosion control around the perimeter of the engineered soil to protect from siltation or contamination from adjacent landscape or paved surfaces and construction activities. Leave erosion control in place until site landscape establishment and construction is complete.

3.9 EROSION MAT

A. Install Erosion Mat on top of surface prior to installation of vegetation.

END OF SECTION

SECTION 32 92 19
SEEDING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Preparation of subsoil.

B. Placing topsoil and compost.

C. Final Seeding and applying stabilizers, mulching material, and fertilizer.

D. Maintenance.

1.2 RELATED REQUIREMENTS

A. Section 31 2500 - Erosion Control: Temporary seeding

1.3 DEFINITIONS

A. Weeds: Include Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.

1.4 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

1.5 REGULATORY REQUIREMENTS

A. Comply with regulatory agencies for fertilizer and herbicide composition.

B. All seed shall conform to the requirements of the Wisconsin Statutes regarding noxious weed seed content. No seed shall be used o the work later than one year after the germination test date which appears on the label.

C. Seed shall be tested when required in accordance with the methods and procedures used in making purity analyses and germination tests as adopted by the US Department of Agriculture in the Administration of the Federal Seed Act.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver grass seed mixture in sealed containers. Seed in damaged packaging is not acceptable. Deliver seed mixture in containers showing percentage of seed mix, year of production, net weight, date of packaging, and location of packaging.

B. Deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer.

PART 2 PRODUCTS

2.1 APPROVED SEED MIXTURES

A. No Mow Turf

1. Unless specified otherwise, Contractor shall supply the No Mow with annual rye variety. The following formulation is as manufactured by Prairie Nursery of Westfield, WI. Any substitution must have prior approval of the Landscape Architect and Owner.

NO MOW WITH ANNUAL RYE	ORIGIN/GERM
SR5130 Chewings Fescue - Festuca communtata - 23.75%	OR-85%
Sheep Fescue - Festuca ovina - 23.44%	Canada - 85%
Chariot Hard Fescue - Festuca longifolia - 11.94%	OR-85%
Heron Hard Fescue - Festuca rubra - 11.85%	OR-85%
Sea Link Creeping Red Fescue - Festuca rubra - 11.82%	OR-85%
SR5250 Creeping Red Fescue - Festuca rubra - 11.68%	OR-85%
Annual Ryegrass - Lolium multiflorum - 3.95%	OR - 90%

2. 1.53% Inert matter
3. .02% other crop seed
4. .02% weed seed
5. Noxious weed seed - none

2.2 SOIL MATERIALS

A. Topsoil: Fertile, agricultural soil, typical for locality, capable of sustaining vigorous plant growth, taken from drained site; free of subsoil, clay or impurities, plants, weeds and roots; pH value of minimum 5.4 and maximum 7.0. or below:

B. Topsoil: Excavated from site and free of weeds.

C. Compost: Well decomposed, stable, weed free; derived from food, agricultural or industrial residuals, biosolids, yard trimmings, or source-separated or mixed solid waste; with no objectionable odors and not resembling the raw material from which it was made; no substances toxic to plants.
1. Gradation: 100 percent passing 3/8 inch screen.
2. Moisture Content: 35 to 55 percent by weight.
3. pH: 5.5 to 8.9.
4. Not more than 1 percent man-made matter and without plastic items more than 2 inches in length.

2.3 ACCESSORIES

A. Mulching Material: Oat or wheat straw, free from weeds, foreign matter detrimental to plant life, and dry. Chopped cornstalks are not acceptable.

B. Fertilizers, intended for use in connection with seeding, sodding, or other planting, shall be standard commercial products conforming to the requirements of the Wisconsin Statues. Native plant seedings or temporary seeding to be followed by native seedings should not be fertilized. Each package of fertilizer shall be plainly marked with the analysis of the phosphoric acid and soluble potash. Fertilizers shall meet the following minimum requirements:
1. Nitrogen, not less than.....10%
2. Phosphoric Acid, not less than.....10%
3. Potash, not less than.....10%

C. Soil Stabilizers: Soil stabilizers intended as soil bonding agents to prevent or minimize erosion.
1. Soil stabilizers must be environmentally benign; harmless to fish, wildlife, and plants; along with being non-toxic and non-combustible at the rate of application specified by the manufacturer. Asphalt based products will not be approved for use. Only products approved for field testing and field tested by Wisconsin Department of Transportation will be approved for use. Soil stabilizers are considered a short term duration (6 month) erosion control device for use on slope 3:1 or flatter. In addition to the above requirements, soil stabilizers must meet the same vegetative density and sediment loss standards as required for erosion mats.
2. Soil stabilizer shall be a polyacrylamide (PAM) and calcium solution intended to reduce the erodability of bare soils during construction activities or to enhance the performance of mulching on permanent slopes. Polyacrylamide Soil Stabilizer shall have proven abilities to bond soil particles, effectively increasing the soil particle size to 1.0 millimeter or larger. It shall reduce the movement of soil through chemical bonding, increase the particle size thus making silt fence more effective, and increase the water absorption of the soil.
3. Polyacrylamide Soil Stabilizers shall conform to the Wisconsin Department of Transportation's Product Acceptability List (PAL) for Soil Stabilizers, Type B. Presently, the only acceptable product is Natural Earth PolyStable Plus, manufactured by Earth & Road.

D. Water: Clean, fresh and free of substances or matter that could inhibit vigorous growth of grass.

E. Erosion Control: Reference Civil drawings and specifications for erosion control products.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that prepared soil base is ready to receive the work of this Section.

3.2 PREPARATION

A. Grading, topsoiling, and fertilizing shall be completed before seeding, except when equipment designed for the purpose is used, the fertilizer and seed mixture may be placed in one operation. The areas to be seeded shall be worked with discs, harrows, or other appropriate equipment until it becomes a reasonably even and loose seed bed immediately in advance of the seeding.

3.3 FERTILIZING

A. Apply fertilizer in accordance with manufacturer's instructions.

3.4 SEEDING

A. The seed mixes shall be applied at the following rates:

SEED MIX	RATE
No Mow Turf	5lbs per 1,000 SF / 220 lbs per Acre

B. Final seeding shall be limited to the following period:
   1. Late August - Mid October

C. Any seeding outside the dates listed above shall be at the risk of the Contractor and reseeding after October 15th or in the spring shall be completed at no additional cost to the City of Madison with the same seed mix that was specified in the contract.

D. Unless otherwise specified, seed may be shown at the option of the Contractor by either Method A or Method B as described below:
   1. Method A: The seed mixture shall be shown by means of equipment adapted to the purpose, or it may be scattered uniformly over the areas to be seeded, and lightly raked or dragged to cover the seeding with approximately one-forth inch of soil. After seeding, the areas shall be lightly rolled or compacted by means of suitable equipment, preferably of the cultipacker type when such equipment can be operated, or by means of light hand tampers.
   2. Method B: Upon the prepared seed bed, the seed shall be sown or spread by means of a stream of spray of water under pressure operated from an approved type of machine designated for that purpose. The selected seed mixture and water shall be placed into a tank, provided within the machine, in sufficient quantities that when the contents of the tank are sprayed on a given area the seed will be uniformly spread at the required rate of application. During the process the contents of the tank shall be keep stirred or agitated to provide uniform distribution of the seed.
   3. Scattering seed by hand shall be done only with satisfactory hand seeders and only at such times when the air is sufficiently quiet to prevent seeds from blowing away.

3.5 MULCHING

A. Mulch shall be placed on those areas which are specified for permanent seeding within three (3) days after the seeding has been completed unless the area is specified to receive erosion matting. Mulch is not required in areas to received erosion matting provided matting is placed within three (3) days of seeding.

B. Mulching operations shall not be performed during periods of excessively high winds which would preclude the proper placing of the mulch.

C. The placed mulch shall be loose enough to allow some sunlight to penetrate and air to slowly circulate but thick enough to shade the ground, conserve soil moisture, and prevent or reduce erosion.

D. The Contractor shall maintain the mulched areas and shall repair any areas damaged by wind, erosion, traffic, fire, or other causes prior to final or partial acceptance of the work under contractor.

E. The Contractor shall perform the work with either Method A or Method B, at the direction of the Landscape Architect and Owner.
   1. Method A: The mulching material shall be uniformly spread over the designated areas to a loose depth of one (1) to two (2) inches, using seventy (70) to ninety (90) pounds of mulch per 1,000 SF. The mulch material from compacted bales shall be well loosened or made fluffy before being spread in place. Unless otherwise directed, mulching operations shall begin at the top of slopes and proceed downward.

a. The mulch cover, except when composed of wood excelsior fiber, shall be securely anchored in place by means of heavy twine fastened by pegs or staples to form a grid of from six (6) to ten (10) feet spacing.

2. Method B: Straw or hay shall be treated with asphalt material blown from a machine, and uniformly deposited over designated areas in one operation.
   a. The mulch shall be placed uniformly over the area to a loose depth of one (1) to two (2) inches, using one and one-half to two tons of mulch per acre and 75 to 100 gallons of emulsified asphalt per ton of straw or hay. Within the above designated limits, the Architect will determine, on the job, the rate of application of the mulch and the asphalt, and the right is reserved for the Architect to vary the rates during mulching operations to produce the desired results.
   b. The machine for placing the mulch shall be of an approved type, which will blow or eject by constant air stream a controlled amount of mulch and which will introduce into the air stream a spray of asphalt to partially coat the straw or hay, producing a spotty tack sufficient to hold together and retain in place the deposited hay or straw.
3. Wood fiber shall be applied in the same manner as straw or hay except that the wood excelsior fiber shall not be treated with asphalt material.
4. Throughout the process, the mulch material shall be fed into the blowing machine to produce a constant and uniform ejection from the discharge spout, operated in a position to produce a mulch of uniform depth and coverage.
5. The mulch material shall not contain moisture in excess of that which will permit uniform feeding through the machine.

3.6 WATERING

A. All seeded areas shall be watered as necessary to meet germination and seed growth as defined in ACCEPTANCE AND GUARANTEE below.

B. The Contractor shall be permitted to delay seeding only when the City of Madison is classified by the U.S. Drought Monitor as D-3 Drought Extreme Status. In these circumstances, the Contractor must seed within 10 days of the end of the D-3 Drought Extreme classification. During this time, the Contractor is required to maintain erosion control until seeded areas are accepted as defined in ACCEPTANCE AND GUARANTEE below.

C. Weekly updates provided by the U.S. Drought Monitor are available at: http://droughtmonitor.unl.edu/Home/StateDroughtMonitor.aspx?WI

3.7 SOIL STABILIZERS

A. Soil stabilizers shall be used on all areas seeded.

B. Application is intended to be done with conventional hydraulic seeding equipment. Polyacrylamide Soil Stabilizer may also be placed through dry spreading. Application rates shall be as recommended by the manufacturer and shall meet the approval of the Architect. In general, rate of application shall be 20 lbs. per acre (0.46 lbs per 1,000 SF).

C. Where soil stabilizers are used in the terrace or near any other pedestrian walk areas, the sidewalk and/or pedestrian walk areas shall be protected to keep the soil stabilizers from being deposited on them. After getting wet, any soil stabilizers on these surfaces can result in a slipping hazard. If soil stabilizers are deposited on a sidewalk the contractor shall clean the sidewalk sufficiently to remove the soil stabilizers. The Contractor shall be aware that conventional methods (sweeping) will not be sufficient to remove the polymer due to the nature of the polymer and other methods (vacuum) will be required to meet this requirement.

D.

3.8 ACCEPTANCE

A. Upon completion of seeding, the Contractor shall request approval from the Architect and Engineer for acceptance of seeded areas for the purposes of issuing the certificate of completion and removal of erosion control devices (including, but not limited to inlet protection, silt sock and/or fence, turbidity barrier and/or silt curtain). If the certificate of completion is authorized by the Architect and Engineer with pending or without acceptance of seeded areas, the Contractor is responsible for maintaining erosion control devices until authorized by the Architect.

B. Acceptance shall be defined as healthy and flourishing germination of 95% of perennial grass seed to a minimum height of 1 inch, with no or few bare patches.

C. All seeded areas which are dead or found not to be in a normal, healthy condition or do not conform to the specifications, in the judgement of the Architect will not be accepted. All rejected work shall be replaced by the Contractor, including removal and repair of all work affected by the replacement, at no cost to the City.

3.9 GUARANTEE

A. All areas that have been seeded with turf shall be guaranteed to be in a healthy and flourishing condition as defined in section 3.8 ACCEPTANCE for a period of 1 year from the date on the certificate of completion.

B. At any time within the period of the guarantee, the Contractor shall replace any seeded areas which, for any reason, have died or are in a dying condition, or which have failed to flourish in such a manner or to such a degree that their usefulness or appearance has been impaired. Replacement shall include removal and repair of all affected work. Seeded areas that have perished for any reason shall be reseeded or overseeded with the exact variety of turf seed that was originally specified.

C. Following the completion of the repair, a re-inspection will be made prior to final acceptance.

END OF SECTION

SECTION 32 92 23

SODDING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Preparation of subsoil.

B. Placing topsoil.

C. Top dressing with compost.

D. Fertilizing.

E. Sod installation.

F. Maintenance.

1.2 RELATED REQUIREMENTS

A. Section 31 2500 - Erosion Control: Temporary seeding

1.3 DEFINITIONS

A. Weeds: Includes Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.

1.4 REFERENCE STANDARDS

A. TPI (SPEC) - Guideline Specifications to Turfgrass Sodding; 2006.

1.5 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Certification: Submit certification of grass species and location of sod source.

1.6 QUALITY ASSURANCE

A. Sod Producer: Company specializing in sod production and harvesting with minimum five years experience, and certified by the State of Wisconsin.

B. Installer Qualifications: Company approved by the sod producer.

1.7 REGULATORY REQUIREMENTS

A. Comply with regulatory agencies for fertilizer and herbicide composition.

B. Provide certificate of compliance from Wisconsin Statutes indicating approval of fertilizer and herbicide mixture.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver sod in rolls or on pallets. Protect exposed roots from dehydration.

B. Do not deliver more sod than can be laid within 24 hours.

PART 2 PRODUCTS

2.1 MATERIALS

A. Sod: Shall consist of a dense, well-rooted growth of permanent and desirable grasses, indigenous to the general locality where it is to be used, and shall be practically free from weeds or undesirable grasses; type indicated below.

1. Black Beauty Tall Fescue Kentucky Bluegrass (TFKB Sod); a 50/50 blend of tall fescue and Kentucky Bluegrass as produced by Paul's Turf and Tree Nursery of Marshall, WI; or approved equal.

a. At the time the sod is cut, the grass on the sod shall have a length of approximately two inches (if longer, the grass shall be cut to approximately this length) and the sod shall have been raked free from debris.
b. The sod shall be cut in uniform strips and be of a uniform thickness; shall have no holes; shall be free of weeds, insects, and diseases; shall be uniformly green and not discolored due to drying or heating, and shall be moist.
c. The thickness of the sod shall be uniform at approximately 1/2 to 3/4 inch depending on the nature of the sod, so that practically all of the dense root system of the grasses will be retained, but exposed, in the sod strip and so that the sod can be handled without undue tearing or breaking.
d. In the event the sod which is to be cut is in a dry condition so as to cause crumbling or breaking during cutting operations, at least twelve (12) hours before cutting the sod, the Contractor, at no additional cost to the City, shall apply water to the sod in sufficient quantities to provide a well moistened condition of the sod to the depth to which is is to be cut.

B. Topsoil: Excavated from site or

C. Topsoil: Fertile, agricultural soil, typical for locality, capable of sustaining vigorous plant growth, taken from drained site; free of subsoil, clay or impurities, plants, weeds and roots; pH value of minimum 5.4 and maximum 7.0.

D. Compost: Well decomposed, stable, weed free, organic matter source. Derived from agricultural, food, or industrial residuals; biosoilds (treated sewage sludge); yard trimmings; source-separated or mixed solid waste. Compost shall contain no substances toxic to plants and shall be reasonably free (<1% by dry weight) of man-made foreign matter. The compost will possess no objectionable odors and shall not resemble the raw material from which is was derived. Compost shall be certified through the US Composting Council's (USCC) Seal of Testing Assurance (STA) Program.
1. pH Range: 6.0-8.5
2. Soluble Salt Concentration: Maximum of 10 dS/m
3. Moisture Content: 30-60% wet weight basis
4. Organic Matter Content: 30-65% dry weight basis
5. Particle Size: 98% passing through 3/4" screen or smaller

E. Fertilizers, intended for use in connection with seeding, sodding, or other planting, shall be standard commercial products conforming to the requirements of the Wisconsin Statues. Native plant seedings or temporary seeding to be followed by native seedings should not be fertilized. Each package of fertilizer shall be plainly marked with the analysis of the phosphoric acid and soluble potash. Fertilizers shall meet the following minimum requirements:
1. Nitrogen, not less than.....10%
2. Phosphoric Acid, not less than.....10%
3. Potash, not less than.....10%

F. Water: Clean, fresh and free of substances or matter that could inhibit vigorous growth of grass.

2.2 ACCESSORIES

A. Wood Pegs: Softwood, twelve (12) inches in length.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that prepared soil base is ready to receive the work of this section.

3.2 PREPARATION

A. Remove any existing vegetation within planting area.

B. Existing soils exposed to construction activity shall be cleaned of any stones, roots, rubble or debris and de-compacted to a depth of 12" minimum.

C. Spread topsoil where existing topsoils have been removed during construction activities.

D. Top dress topsoils with 1/2" compost

E. Till soils to a depth of 4", rake and remove any additional debris or rubble, smooth soil surface

F. Lightly roll soil

3.3 FERTILIZING

A. Apply fertilizer in accordance with manufacturer's instructions.

B. Apply after smooth raking of topsoil and prior to installation of sod.

C. Apply fertilizer no more than 48 hours before laying sod.

D. Mix thoroughly into upper 2 inches of topsoil.

E. Lightly water to aid the dissipation of fertilizer.

3.4 LAYING SOD

A. Frozen sod shall not be placed, nor shall any sod be placed upon frozen soil.

B. Moisten prepared surface immediately prior to laying sod.

C. Lay sod immediately after delivery to site to prevent deterioration.

D. Lay sod smooth and tight with no open joints visible, and no overlapping; stagger end joints 12 inches minimum. Do not stretch or overlap sod pieces.

E. As the sod is being laid it shall be rolled or firmly, but lightly, tamped with a suitable wooden or metal tampers, sufficiently only to 'set' or press the sod into the underlaying soil.

F. Where new sod adjoins existing grass areas, align top surfaces.

G. Where sod is placed adjacent to hard surfaces, such as curbs, pavements, etc., place top elevation of sod 1 inch below top of hard surface.

H. On all slopes steeper than one foot vertical to four feet horizontal, the sod shall be staked or pegged with wooden stakes spaced as required by the nature of the soil and steepness of slope, from 18 inches to 36 inches apart along the longitudinal axis of the sod strip. Stakes shall preferably be placed near the top edges of the sod strip and shall be driven approximately plumb through the sod to be almost flush with the sod.

I. All sod placed in ditches, flumes, or other appurtenances, where a concentrated flow of water may be expected, shall be staked regardless of slopes.

J. At points where water will flow over a sodded area, the upper edges of the sod strips shall be turned into the soil below the adjacent area and a layer of earth placed over this juncture, which earth shall be thoroughly compacted to conduct the surface water over the upper edge of the sod.

K. At the limits of sodded areas, wherever practical or feasible, the end strips shall be placed to effect a broken line, and ends of the strips shall be turned in and treated as described above.

L. Water sodded areas immediately after installation. Saturate sod to 4 inches of soil.

M. During periods of extreme drought, defined as category D-3 Drought Extreme by the U.S. Drought Monitor, the Contractor shall refrain from installing sod until after the City of Madison is no longer within this classification. The Contractor must install sod within ten (10) days of the end of the D-3 Drought Extreme Classification. During this time, the Contractor must maintain all perimeter erosion control until directed by the Architect and Engineer.

3.5 WATERING

A. After staking and cleanup, the sod shall be thoroughly moistened by sprinkling with water. All sodded areas shall be kept thoroughly moist by watering or sprinkling when rainfall is not sufficient to achieve rooting of the sod to the earth bed. Water shall be applied in a manner to preclude washing to erosion.

B. No additional compensation will be given to Contractors for watering related to dry conditions, except as specified in subsection 3.6 Drought Watering.

3.6 DROUGHT WATERING

A. The Contractor shall receive additional compensation for watering required to keep sod in flourishing condition ONLLY when the following conditions are present and have been met:

1. The U.S. Drought Monitor has classified the City of Madison as D-3 Drought Extreme status. Weekly updates provided by the U.S. Drought Monitor are available at: http://droughtmonitor.unl.edu/Home/StateDroughtMonitor.aspx?WI
2. The sod was installed greater than ten (10) days from the date seeking additional compensation.

B. Once the U.S. Drought Monitor has classified the City of Madison as D-3 Drought Extreme, the Contractor must notify the Architect of the dates of additional watering(s) to occur within the next seven (7) days, and of watering(s) that occurred seven (7) days prior to classification of the D-3 Drought Extreme Classification. The Contractor shall receive compensation for up to four (4) additional drought waterings performed seven (7) days prior to the classification f D-3 Drought Extreme and four (4) additional waterings during the seven (7) day period after the U.S. Drought Monitor has classified the City of Madison as D-3 Drought Extreme. The Contractor will not receive double payments for waterings during periods of consecutive weeks of D-3 Drought Extreme Status.

C. The request for additional watering(s) will be made on a weekly basis according to the weekly reports from the U.S. Drought Monitor.

D. In the event that there is a significant rainfall (> 1"), after the U.S. Drought Monitor has classified the City of Madison as D-3 Drought Extreme, the Contractor must notify the Architect of the revised dates of additional watering(s) that will occur within the next seven (7) days.

E. The Architect shall not be held responsible for informing the Contractor that additional watering(s) are necessary because of the D-3 Drought Extreme status by the U.S. Drought Monitor. Plants that perish or do not thrive because of lack of watering(s) shall be the responsibility of the Contractor per below sections ACCEPTANCE and GUARANTEE.

3.7 ACCEPTANCE

A. Upon completion of all required sodding, an inspection of the work will be made by the Architect. All sodded areas which are dead or found not to be in a normal, healthy condition or do not conform to specifications, in the judgement of the Architect will not be accepted. All rejected work shall be replaced by the Contractor, including removal and repair of all work affected by the replacement, at no cost to the City.

3.8 GUARANTEE

A. All areas that have been sodded shall be guaranteed to be in a healthy and flourishing condition for a period of 1 year from the date on the certificate of completion.

B. At any time within the period of the guarantee, the Contractor shall replace any sodded areas which, for any reason, have died or are in a dying condition, or which has failed to flourish in such a manner or to such a degree that its usefulness or appearance has been impaired. Replacement shall include removal and repair of all affected work. Sodded areas that have perished for any reason shall be resodded with the exact variety of sod that was originally installed.

C. Following the completion of the repair, a re-inspection will be made prior to final acceptance.

END OF SECTION

SECTION 32 93 00

PLANTS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Preparation of subsoil.

B. Topsoil.

C. Compost top-dressing.

D. New trees and plants.

E. Mulch and Fertilizer.

F. Accessories

G. Tree Pruning.

1.2 DEFINITIONS

A. Weeds: Include Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.

B. Plants: Living trees, plants, and ground cover specified in this Section, and described in ANSI Z60.1.

1.3 REFERENCE STANDARDS

A. ANSI/AHIA Z60.1 - American National Standard for Nursery Stock; 2014.

B. ANSI A300 Part 1 - American National Standard for Tree Care Operations -- Tree, Shrub and Other Woody Plant Maintenance -- Standard Practices; 2008 (R2014).

C. Standardized Plant Names - 1942, American Joint Committee on Horticulture Nomenclature.

D. Pruning Standards for Shade Trees - current edition, National Arborist Association.

1.4 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Submit list of plant life sources.

1.5 QUALITY ASSURANCE

A. Nursery Qualifications: Company specializing in growing and cultivating the plants with a minimum of 5 years documented experience.

B. Installer Qualifications: Company specializing in installing and planting the plants with a minimum of 5 years experience.

C. Tree Pruner Qualifications: Company specializing in pruning trees with proof of Arborist Certification.

D. Maintenance Services: Performed by installer.

1.6 REGULATORY REQUIREMENTS

A. Comply with regulatory agencies for fertilizer and herbicide composition.

B. Provide certificate of compliance from authority having jurisdiction indicating approval of plants, fertilizer and herbicide mixture.

C. Plant Materials: Certified by federal department of agriculture; free of disease or hazardous insects.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer.

B. Protect and maintain plant life until planted.

C. Deliver plant life materials immediately prior to placement. Keep plants moist.

1.8 FIELD CONDITIONS

A. Do not install plant life when ambient temperatures may drop below 35 degrees F or rise above 90 degrees F.

B. Do not install plant life when wind velocity exceeds 30 mph.

PART 2 PRODUCTS

2.1 PLANTS

A. Plants: All plants shall be typical of their species and have well-formed tops (crowns) and root systems and shall be free from injurious insects, plant diseases, or other plant pests. All plants shall be grown within the States of Wisconsin, Minnesota, Iowa, Michigan, or the parts of Illinois, Indiana, or Ohio located within Zone 5 of the Plant Hardiness Zone Map of the USDA. Plants furnished shall conform to the American Standard for Nursery Stock and be free from the following defects:
   1. Serious injuries to leader, branches (crown), trunk, bark, or roots
   2. Dried out roots
   3. Girdling or encircling roots
   4. Prematurely opened buds
   5. Thin or poor tops (crowns) or root systems
   6. Evidence of molding
   7. Dry, loose, or broken ball of earth in balled and burlapped (B&B) stock
   8. Dried out or damaged soil mass in bare root (BR), balled and burlapped (B&B), or container grown (CG) stock

B. Grading Standards: Plant stock shall conform to the code of standards set forth in the current edition of the American Standards for Nursery Stock.

2.2 SOIL MATERIALS

A. Topsoil: Excavated from site to the greatest extent possible and supplemented with the below as necessary.

B. Topsoil: Fertile, agricultural soil, typical for locality, capable of sustaining vigorous plant growth, taken from drained site; free of subsoil, clay or impurities, plants, weeds and roots; minimum pH value of 5.4 and maximum 7.0.

C. Compost: Well decomposed, stable, weed free; derived from food, agricultural or industrial residuals, biosolids, yard trimmings, or source-separated or mixed solid waste; with no objectionable odors and not resembling the raw material from which it was made; no substances toxic to plants.
   1. Gradation: 100 percent passing 3/8 inch screen.
   2. Moisture Content: 35 to 55 percent by weight.
   3. pH: 5.5 to 8.9.
   4. Not more than 1 percent man-made matter and without plastic items more than 2 inches in length.

D. Planting Soil: a unform blend consisting of 50% topsoil, 30% course sand, and 20% compost. Place topsoil in 12 inch lifts and water in to review drainage and prevent future settlement.

2.3 SOIL AMENDMENT MATERIALS

A. Fertilizer: When/where specified, shall be of the slow release type contained in polyethylene perforated bags with micropore holes. Each bag shall contain a minimum of one (1) once of soluble fertilizer with an analysis of 16-8-16 per unit or approved equal. The minimum guaranteed analysis shall be total nitrogen 16%; 9% ammoniacal nitrogen, 7% nitrate nitrogen. Available phosphoric acid P2 O5 (from ammonium phosphate) 8%, soluble potash (from potassium chloride) 16%.

2.4 MULCH MATERIALS

A. Organic Mulch: Shredded Cedar Mulch free of coloring agents or objectionable foreign material.

2.5 ACCESSORIES

A. Wrapping: When/where specified, shall consist of a two-ply waterproofed crepe tree wrapping paper, laminated with a layer of pliable asphalt material. The wrap shall tightly cover the entire surface of the trunk, overlapped one

and one-half inches in spiral fashion, starting at the base of the tree and extending to the height of the first branches. The wrapping shall be secured in at least three (3) places with masking tape. The Contractor shall be responsible for removing and disposing of the tree wrap after a one year period.

B. Protection: When/where specified, shall consist of galvanized hardware cloth, extruded aluminum mesh or a durable pre-formed plastic material. The hardware cloth or aluminum mesh, if used, shall have at least three meshes per linear inch and shall be used in conjunction with a steel rod having a minimum size of 3/8" x 48". The plastic material shall be a durable, resilient, preformed plastic spiral acceptable to the Architect. Such material shall have a natural, earth-tone color. The Contractor shall be responsible for removing and disposing of the protection at the end of the guarantee period unless otherwise specified by the Architect.

C. Below-Grade Tree Stabilizing System, similar or equal to:
   1. Tree Staple Stabilizer, manufactured by Tree Staple Inc., 877-873-3749, www.treestaple.com

D. Weed Barrier Fabric: 5 oz., woven, needlepunched, polypropylene fabric with ground anchoring pins. Limit use to areas described in landscape details.

E. Landscape Edging: Concrete 'bullet' style edgers, approximately 4"h x 12"l x 4"d with one rounded and one concave end for alignment. Color: Charcoal gray. Set in straight line with outer face of edger in alignment with outside edge of adjacent pavement where applicable.

F. Anti-Desiccant: When/where specified, shall be an approved emulsion which will provide a film over plant surfaces permeable enough to permit transpiration.

G. Watering Equipment: The Contractor shall furnish and have available sufficient watering equipment, including tanks, pumps, hoses, root feeders, and incidentals to fully perform all of the watering. Water will be furnished to the Contractor by the City from existing facilities if requested by the Contractor in accordance with these specifications. When the Contractor chooses to use City of Madison water for any part of the project, then the Contractor must proceed as follows:
   1. Request Water Utility in install valve on convenient hydrant
   2. Agree to pay Water Utility charges for installation, use, and removal of the valve
   3. Notify Water Utility immediately when use of valve is no longer necessary.
   4. The Contractor shall not make connections to the Water Utility facilities without permission from the Water Utility.

2.6 SOURCE QUALITY CONTROL

A. Substitution: Where evidence is submitted that a specified plant cannot be obtained, substitution may be made only upon specific approval of the Architect.

B. Inspection and Approval of All Plant Material: All plants shall be subject to the approval of the Architect. Trees that will be inspected and tagged at the nursery or place of collection will be done at a time agreeable to the Contractor and Architect. Approval of plants at the source does not alter the right of rejection at the project site. It is the right of the Architect to reject plant material(s) at the project site. It is the responsibility of the Contractor to notify the Architect forty-eight (48) hours prior to any plantings, as to which plants are to be planted and their location(s). Contractor shall furnish to the Architect an invoice or order form from each nursery indicating the sources from which he proposes to obtain plant materials for the work at this time confirming what will be delivered. This list shall include species name, cultivar, root condition, and size. All plants shall conform to the measurements specified in the plant list. Measurements specified shall be the minimum size acceptable for each variety. Plants that meet the requirements specified in the itemized plant list, but that do not possess a normal balance between height and spread, will not be accepted. Plants shall not be pruned prior to delivery. Tree branching shall be evenly spaced around the trunk without excessive gaps between the whorls. Trees with multiple leaders, unless specified, will be rejected. Central leaders shall be left intact.

PART 3 EXECUTION

3.1 GENERAL

A. All plant stock shall be freshly dug and handled with care to prevent injuries to the leaders, branches, trunk, and roots.

3.2 DIGGING AND HANDLING OF PLANT MATERIAL

A. Care shall be taken to prevent any damage to plant material during transit and handling. The Architect shall check trees for any shipping or handling damages. Trees with excessive damage as determined by the Architect shall be rejected.

B. Plant stock to be furnished balled and burlapped (B&B) shall be moved with a compact dug ball of earth so firmly wrapped in burlap that upon delivery the soil in the ball is still firm and compact about the root system. Each ball shall be of sufficient size to encompass all the fibrous roots necessary to ensure successful recovery and development of the plant. Root balls shall not be allowed to dry out between digging and planting. The minimum sizes of balls, ball depth and diameters, and increased ball sizes for collected stock shall be in accordance with Recommended Balling and Burlapping Specifications as set forth in the current edition of the American Association of Nurserymen. No plant will be accepted when the burlap, twine, wire, or ropes required to secure the root ball have been removed. Ropes, strings, wire baskets, burlap, and other wrappings shall be removed from the entire plant before installation is complete. The balance of the wrappings may be left intact around the bottom of the ball. All balled and burlapped plants than cannot be planted immediately on delivery shall be set on the ground and the balls covered with soil or other acceptable mulch material and shall be kept moist until planted.

C. Plants marked 'CONT.' shall be container grown with a well-established root system. Container grown plants are to be well-established within the container, with a root system sufficiently developed to retain its shape and hold together when removed from the container. Roots should be be noticeable when removed from the container, but not protruding outside the container. Soil within the container should be held together by the roots, in form and whole. Plants shall not be bound nor have kinked, circling, or bent roots.

D. All plants shall be handled so that the roots are adequately protected at all times. During shipment, all plants shall be properly protected by a tarpaulin or other suitable covering. No plant shall be so bound with rope or wire at any time as to damage the bark, break branches, or destroy its natural shape.

3.3 EXAMINATION

A. Plants shall be marked for identification and for checking as designated on the plant list. Each grouping of plants and all separate plants shall have legible, waterproof labels securely attached thereto before delivery to the site.

B. Prior to any excavation, the Contractor shall notify Diggers Hotline at 1-800-242-8511 to determine the location of all electric, gas, water, sewer, oil, and other utility lines, including tanks or other subsurface encumbrances, and precautions shall be taken by the Contractor not to disturb or damage any utility lines. In the event of a conflict of a utility with the planting, the Contractor shall promptly request, in writing, from the Architect a revised location for plant material.

C. Verify that prepared subsoil is ready to receive work.

D. Saturate soil with water to test drainage.

3.4 PREPARATION OF SUBSOIL

A. Prepare subsoil to eliminate uneven areas. Maintain profiles and contours. Make changes in grade gradual. Blend slopes into level areas.

B. Remove foreign materials, weeds and undesirable plants and their roots. Remove contaminated subsoil.

C. Scarify subsoil to a depth of 4 inches where plants are to be placed. Repeat cultivation in areas where equipment, used for hauling and spreading topsoil, has compacted subsoil.

3.5 PLACING TOPSOIL AND COMPOST

A. Spread topsoil to a minimum depth of 12 inches over area to be planted. Rake smooth.

B. Place topsoil during dry weather and on dry unfrozen subgrade.

C. Remove vegetable matter and foreign non-organic material from topsoil while spreading.

D. Grade topsoil to eliminate rough, low or soft areas, and to ensure positive drainage.

E. Top dress topsoil with 1 inch of compost.

F. Mix compost into topsoil to a depth of 6 inches.

G. Rake and smooth soils to 3 inches below finish grade to allow for placement of mulch.

3.6 FERTILIZING

A. Apply fertilizer in accordance with manufacturer's instructions.

B. Apply after initial raking of topsoil.

C. Mix thoroughly into upper 2 inches of topsoil.

D. Lightly water to aid the dissipation of fertilizer.

3.7 PLANTING

A. Planting Dates - Unless otherwise specified on plans, the planting seasons are as follows:
   1. Deciduous grass, or perennial container grown plants may be planted from the time frost is out of the ground through October 15th.
   2. Fall planting season for deciduous trees shall begin no earlier than October 1st
   3. Fall planting for evergreen trees and shrubs shall be done between August 15th and September 15th

B. Unless otherwise approved, planting shall not be done when the ground is frozen or when soil is in an unsatisfactory condition for planting.

C. Contractor to locate trees, shrubs, and perennial groupings as shown on plans.

D. Set plants vertical.

E. For plants in containers, the container shall be removed before planting. If roots are crowded or coiled on the bottom, sides, or surface of the root ball, they shall be gently separated from the edges or surface.

F. Balled and burlapped plants shall have the ropes, strings, wire baskets, burlap, and other wrappings removed from the top 1/2 of the ball after the plant has been set. The balance of the wrappings may be left intact around the bottom of the ball.

G. Plants shall be set with the root flare at the finished grade (root flare shall be determined 1" above the upper-most woody support root).

H. Planting holes shall be backfilled with excavated soil. Salvaged topsoil shall be placed in layers around the roots or ball. Frozen or muddy soil will not be acceptable backfill material. Backfilling shall be carefully done to avoid injury to the roots or ball without disturbing the position of the plant. When holes are approximately 2/3's full, they shall be thoroughly watered to eliminate air pockets. Once water has drained from the hole, complete backfilling to the top of the hole and again water thoroughly. Puddled soil conditions shall be avoided.

I. At deciduous and evergreen tree plantings, install below-grade tree stabilizing system per manufacturer's recommendations.

J. Planting areas shall be finish-graded to conform to drawings after full settlement has occurred.

K. All plants shall be mulched to a depth of 3" to the extents shown on the plans.

3.8 TREE PRUNING

A. Perform pruning of trees as recommended in ANSI A300.

B. Prune newly planted trees as required to remove dead, broken, and split branches.

3.9 CARE

A. The Contractor shall properly care for all plants while the payment and performance bond remains in effect. The performance and payment bond shall remain in effect for one year from the date on the certificate of completion.

B. Proper care of plants shall consist of doing such watering, weeding, cultivating, pruning, spraying, resetting of stabilizing systems, wrapping, re-mulching, and such other work as may be necessary to keep the plants in a neat appearance and in a healthy growing condition. No additional compensation will be given to Contractors for watering related to dry conditions, except as specified in subsection 3.10 DROUGHT WATERING.

C. It shall be the Contractor's responsibility to thoroughly water and care for plants, especially during the ten (10) day period after initial planting. No additional compensation will be given for watering during the first ten (10) days of initial planting, regardless of drought status.

D. Additional waterings may be ordered by the Architect at any time, for the duration of the guarantee period. Should conditions require such waterings, Contractor shall water within three (3) days of notification. The volume of each

watering and intervals between waterings shall depend upon weather conditions and soil moisture. Contractor shall monitor weather and soil condition at each planting.

E. Care must be taken when watering not to wash away mulch and topsoil. Mulch and topsoil displaced by the Contractor must be replaced immediately and at no additional cost to the City.

F. Street trees shall be pruned by the City Forester.

3.10 DROUGHT WATERING

A. The Contractor shall receive additional compensation for watering required to keep plants in a healthy growing condition ONLY when the following conditions are present and have been met:
   1. The U.S. Drought Monitor has classified the City of Madison as D-3 Drought Extreme status. Weekly updates provided by the U.S. Drought Monitor are available at: http://droughtmonitor.unl.edu/Home/StateDroughtMonitor.aspx?WI
   2. The plantings were installed greater than ten (10) days from the date seeking additional compensation.

B. Once the U.S. Drought Monitor has classified the City of Madison as D-3 Drought Extreme, the Contractor must notify the Architect of the dates of additional watering(s) to occur within the next seven (7) days, and of watering(s) that occurred seven (7) days prior to classification of the D-3 Drought Extreme Classification. The Contractor shall receive compensation for up to four (4) additional drought waterings performed seven (7) days prior to the classification f D-3 Drought Extreme and four (4) additional waterings during the seven (7) day period after the U.S. Drought Monitor has classified the City of Madison as D-3 Drought Extreme. The Contractor will not receive double payments for waterings during periods of consecutive weeks of D-3 Drought Extreme Status.

C. The request for additional watering(s) will be made on a weekly basis according to the weekly reports from the U.S. Drought Monitor.

D. In the event that there is a significant rainfall (> 1"), after the U.S. Drought Monitor has classified the City of Madison as D-3 Drought Extreme, the Contractor must notify the Architect of the revised dates of additional watering(s) that will occur within the next seven (7) days.

E. The Architect shall not be held responsible for informing the Contractor that additional watering(s) are necessary because of the D-3 Drought Extreme status by the U.S. Drought Monitor. Plants that perish or do not thrive because of lack of watering(s) shall be the responsibility of the Contractor per below sections ACCEPTANCE and GUARANTEE.

3.11 ACCEPTANCE

A. Upon completion of all required planting, and inspection of the work will be made by the Architect. All plants which are dead or found not to be in a normal, healthy condition or do not conform to specifications, in the judgement of the Architect, will not be accepted. All rejected work shall be replaced by the Contractor, including removal and repair of all work affected by the replacement, at no cost to the City.

3.12 GUARANTEE

A. Plants shall be guaranteed for two years from the date on the certificate of completion.

B. At any time within the period of the guarantee, the Contractor shall replace any plant which, for any reason, has died or is in a dying condition, or which has failed to flourish in such a manor or to such a degree that its usefulness or appearance has been impaired. Replacement shall include removal and repair of all affected work. The decision of the City as to the necessity of replacing any plants shall be conclusive and binding on the Contractor. No more than two (2) replacements per plant shall be required after acceptance.

C. Following completion of the replacements, a re-inspection will be made prior to final acceptance.

D. All replacement plantings are to be selected and tagged by the Architect prior to being brought to the job site. It is the responsibility of the Contractor to notify the Architect forty-eight (48) hours prior to any replacement plantings as to what they are to be planting and in what location.

E. Prior to the termination of the guarantee period, the Contractor shall request a final inspection by the City. All plants found unacceptable for reasons herein before stated shall be replaced at the first planting season and thereafter the responsibility for such plants or material shall lie with the City, no additional guarantee period will be required for these plantings.

END OF SECTION

SECTION 33 11 00
WATER UTILITY DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 SCOPE

A. This section includes information common to water distribution system components and applies to all sections in this Division.

B. Madison Water Utility shall be involved in the following tasks, but are not necessarily limited to, water main filling, flushing, testing, and live-tap installations. Schedule all Water Utility supplemental construction services to occur between the hours of 7:00 AM and 3:00 PM, Monday through Friday. Requests for construction services occurring outside of these hours will be subject to any associated overtime charges being billed to the Contractor. Madison Water Utility reserves the right to decline any construction services which are requested to occur outside of the approved hours. No live-tap installations shall be scheduled to occur outside of the approved hours unless authorized in writing by Madison Water Utility.

C. Contractor shall be solely responsible for obtaining all permits necessary to complete the work. Contractor shall pay all fees associated with obtaining permits. These include, but are not limited to permits for work within public right-of-way, street opening permits, testing, utility connection permits, plumbing permits and municipal fees for completing work (e.g. live taps and water connections to City main).

D. All work shall conform to the City of Madison's Standard Specifications Part VII – Water Mains and Service Laterals. The specifications can be found here: http://www.cityofmadison.com/business/pw/documents/StdSpecs/2017/Part7.pdf

END OF SECTION

SECTION 33 30 00
SANITARY SEWERAGE UTILITIES

PART 1 - GENERAL

1.1 SCOPE

A. This section includes information common to sanitary sewage utilities and applies to all sections in this Division.

B. This specification shall apply to all sanitary sewer work beginning at a point five 5' outside of the building wall, unless otherwise specified.

C. Construct sewer system in a manner that will facilitate future extension or connection.

D. Review plans prior to installation, and notify Construction Representative if proposed design does not appear to accommodate future extension or connection.

E. When drawings indicate future connection at a manhole or other structure, install a full length of pipe beyond the structure, providing plugged bell at terminal end of pipe. Provide marker board at terminal end of stubbed pipe.

F. Contractor, prior to excavation work, shall notify all utilities, governmental agencies, or entities, known to, or which can reasonably be assumed to, have above or below ground pipe, conduit cables, structures or similar items within limits of project, to locate and mark location of such items. The Contractor shall expose potential pipe conflicts prior to installation of sewers to allow for any field changes to the design to be made.

1.2 REFERENCE STANDARDS

A. Work under this section depends on applicable provisions from other sections and the plan set in this contract. Examples of related sections include, but are not limited to:

1. Division 31 — Earthwork

B. ASTM - American Society for Testing and Materials

1. ASTM C425-04 Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings

2. ASTM C700-05 Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated

3. ASTM D1784-03 Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated

4. ASTM Poly(Vinyl Chloride) (CPVC) Compounds

5. ASTM D2235-04 Standard Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings

6. ASTM D2564-04 Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems

7. ASTM D2680-01 Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) and Poly(Vinyl Chloride) (PVC) Composite Sewer Piping

8. ASTM D3034-04a Standard Specification for Type PSM Poly (VinylChloride) (PVC) Sewer Pipe and Fittings

9. ASTM D3212-96a(2003)e1 Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals

10. ASTM D3350-05 Standard Specification for Polyethylene Plastics Pipe and Fittings Materials

11. ASTM D4673-02 Standard Classification System for Acrylonitrile-Butadiene-Styrene (ABS) Plastics and Alloys Molding and Extrusion Materials

12. ASTM F477-02e1 Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

13. ASTM F679-03 Standard Specification for Poly Vinyl Chloride (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings

C. AWWA - American Water Works Association

1. AWWA C104/ANSI A21.4-95 Standard For Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water

2. AWWA C151/ANSIA21.53-00 Standard for Ductile Iron Pipe, Centrifugally Cast for Water or Other Liquids

3. AWWA C153/A21.53 Standard for Ductile Iron Compact Fittings for Water Service

D. Where these specifications do not cover portions of the work to be undertaken, the City of Madison Standard Specifications for Public Works Construction, current edition, shall govern the work, hereafter called "Standard Specifications" in this spec section.

1.3 SUBMITTALS

A. Provide reports documenting pressure testing, mandreling, and televising.

B. Maintain record drawings that show the actual locations, sizes, and types of utilities and other features encountered.

C. Note any modifications to proposed sewer system size, location, or elevation. Record any other deviations from the drawings. Record drawings shall be in compliance with specification section 01 78 39 Asbuilt Drawings. Record drawings shall also include digital record site plans generated by the land surveyor contractor.

PART 2 - PRODUCTS

2.1 PIPE

A. Provide the size, type, and class/schedule of pipe as indicated on the drawings.

B. Use only pipe supplied from the same manufacturer, and of the same type, unless otherwise specified or approved in advance by the Engineer.

C. Only pipe, joints, material and installation approved by Wisconsin Department of Natural Resources and/or the Department of Commerce for the intended use in the State of Wisconsin shall be used.

D. Install all pipe in accordance with ASTM specifications which pertain to the specified type of pipe material and the installation situation.

E. Do not use any pipe or fittings cracked in cutting or handling or otherwise not free from defects.

F. Clean all pipe of any dirt and/or debris both inside and out prior to placing in the trench.

G. Make joints in accordance with manufacturer's directions with due care to avoid damaging pipe and/or disturbing previously laid pipe.

H. Cut pipe only according to manufacturer's directions.

I. Lay all sewer pipes to horizontal alignment and grade shown on the plans with bell ends up hill. Establish and maintain horizontal alignment using total station, transit or theodolite. Use pipe laser or level to establish and maintain grade of pipe. Discrepancies from the required horizontal alignment or grade at any location shall not be greater than 0.10' or 0.05', respectively.

J. Do not exceed specified trench widths.

2.2 PVC PIPE

A. Polyvinyl Chloride (PVC) pipe fittings shall meet the requirements for type PSM Polyvinyl Chloride (PVC) Sewer Pipe and Fittings of ASTM D3034 for pipe sizes up through 15 inches and ASTM F679 for pipe sizes 18 inches through 36 inches. All PVC sanitary sewer pipe shall have a maximum standard dimension ratio (SDR) of 35.

B. The wall thickness shall conform to requirements for a T-1 wall per ASTM F69-01. PVC material shall have cell classification 12454-B or 12454-C as defined in ASTM D1784 with minimum modulus of elasticity of 400,000 psi in tension. Pipe stiffness shall be minimum 46 psi when tested in accordance with ASTM D2412.

C. Acceptance of piping shall be subject to tests conducted by an approved testing agency.

D. Pipe and fittings shall be the product of one manufacturer and the manufacturer shall have experience records substantiating acceptable performance of the pipe to be furnished.

E. Fittings such as saddles, elbows, tees, wyes and others shall be of material and construction corresponding to and have a joint design compatible with the adjacent pipe. Approved adapters shall be provided for transitions to other types of pipe. Fittings shall be injection molded PVC.

F. Joints shall be of the elastomeric type. Elastomeric joints shall be a bell and spigot joint conforming to ASTM D3212 sealed by a rubber gasket conforming to ASTM F477 so that the assembly will remain watertight under all conditions of service, including the movements resulting from the expansion, contraction, settlement, and deformation of the pipe. Bells shall be formed integrally with the pipe and shall contain a factory installed positively restrained gasket.

2.3 CONNECTIONS FOR DISSIMILAR PIPE MATERIALS

A. Where new sewer connects to and existing dissimilar pipe, the connection shall be made with a no hub type coupling meeting the requirements of CISPI 310. Couplings shall have neoprene gaskets with stainless steel shield, and multiple stainless steel clamps with worm gear tightening device. The couplings shall be made specifically for the type and size of pipe materials being connected. Couplings shall be Fernco RC Strongback.

2.4 PIPE INSULATION

A. Rigid closed-cell extruded polystyrene insulation shall be suitable for buried insulation.

B. Individual boards shall have dimensions of 8" x 4" x 2".

C. Insulation shall follow the requirements of COMM Code82.

D. Dow Styrofoam, or approved equal.

E. Provide insulation when indicated on the drawings or where depth of cover is less than 6'. Unless otherwise noted, install 2" thick polystyrene board insulation.

F. Install insulation on compacted initial cover material, 6" above the top of pipe. Stagger joints where more than one layer of insulation is required. Provide insulation with a minimum of 1' of initial cover material. Place cover and backfill material in a manner that does not damage insulation; replace any damaged insulation.

PART 3 - EXECUTION

3.1 BEDDING/INITIAL COVER

A. Sanitary sewer and sewer services shall be provided with 4" of bedding material and 12" of initial cover material (both measured at the bell of the pipe).

B. Crushed stone bedding shall be used for both bedding and initial cover.

C. Backfill within paved areas of R.O.W. shall consist of aggregate slurry.

3.2 CONNECTIONS TO EXISTING STRUCTURES

A. Make all necessary openings into existing structures or sewers including the reconstruction of existing inverts or benches, as necessary. Patch all openings permanently watertight with concrete brick and mortar, or hydraulic cement and water stops, or for sanitary sewer, hydraulic cement and flexible water tight boots.

3.3 SEWER LATERALS

A. Connect existing sewer laterals in accordance with all of the requirements of the sewer mains, including bedding, backfill, compaction and jointing of the pipe. Connect sewer laterals to the sewer main by means of an approved "wye" fitting. Connect the new pipe to the existing lateral material using a no-hub coupling or approved transition fitting. Coupling/fitting shall be selected for the specific pipe material being connected.

B. Subject to local municipality requirements, cut-in type saddle wyes are permitted on existing sanitary sewers where service laterals are to be connected to the sewer. Unless otherwise indicated, the saddle fitting shall be gasketed PVC with stainless steel bands and hardware.

3.4 ELECTRONIC MARKERS OVER LATERAL

A. Each sanitary lateral shall have a minimum of 2 electronic markers: One shall be located above the wye on the sewer main, and one shall be located above the lateral at the property line. Additional markers shall be placed at each change in horizontal direction. Markers shall be installed per manufacturer's written instruction.

B. The key constraint is the maximum depth of the marker. The signal range of the 3M™ Electronic Marker System (EMS) 4" EXTENDED RANGE 5' BALL MARKER - WASTEWATER (MODEL 1404-XR) is 5 feet.

C. Upon completion, the City will test each electronic marker to confirm that it is installed and functioning properly. If it is determined that the marker has not been installed correctly and/or is not functioning properly, the contractor will be responsible for the all work associated with the installation of a properly functioning marker.

3.5 LEAKAGE TESTING

A. All new sanitary sewer lines shall be leakage tested in accordance with the Low Pressure Air Test per 501.3(b).

3.6 SEWER TELEVISING

A. Sanitary sewers may be videotaped by OWNER. If videotaping reveals a defect that requires repair, CONTRACTOR shall reimburse OWNER for cost of videotaping that section of pipe. All sanitary sewers with defects, including but not limited to cracked or deformed pipe, misaligned joints, unsealed lift holes, and incorrect gradelines, as identified through videotaping, shall be re-laid or shall be paid for at 50% of the price bid. Relaying the pipe or reducing payment shall be at OWNER's discretion.

B. The Contractor shall provide to the Construction Representative with 2 copies of the televising tape or DVD.

3.7 ABANDON SEWER

A. Where indicated on the plans, existing sewer to be left in

B. Place shall be abandoned in accordance with the Standard Specifications. Sewer shall not be abandoned until existing services have been reconnected to the replacement sewer. Abandoning sewers is considered incidental to the construction.

C. In paved areas or current/future building pad areas, existing storm sewer facilities are required to be abandoned as follows:

1. Remove existing pipes or fill them with sand or grout and seal ends with a minimum 2-foot thick grout plug.

2. Remove existing inlets, catch basins, and manholes to at least 4 feet below finished grade. Provide a minimum 6 inch hole in the bottom of the structure and fill the remaining portion with bedding stone.

END OF SECTION

SECTION 33 40 00
STORM DRAINAGE UTILITIES

PART 1 - GENERAL

1.1 SCOPE

A. This section includes information common to storm drainage utilities and applies to all sections in this Division.

B. The work under this section shall consist of providing all work, materials, labor, equipment, and supervision necessary to provide for the storm sewer work required in these specifications and on the drawings. This specification shall apply to all storm sewer work beginning at a point 5' outside of the building wall, unless otherwise specified.

C. Construct sewer system to convey flow from the bioretention areas.

D. Review plans prior to installation, and notify Construction Representative of any concerns.

E. Contractor, prior to excavation work, shall notify all utilities, governmental agencies, or entities, known to, or which can reasonably be assumed to, have above or below ground pipe, conduit cables, structures or similar items within limits of project, to locate and mark location of such items. The Contractor shall expose potential pipe conflicts prior to installation of sewers to allow for any field changes to the design to be made.

1.2 REFERENCES

A. Work under this section depends on applicable provisions from other sections and the plan set in this contract. Examples of related sections include, but are not limited to:

1. Division 31 — Earthwork

B. ASTM - American Society for Testing and Materials

1. ASTM C76-05b Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe

2. ASTM C443-05a Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets

C. Where these specifications do not cover portions of the work to be undertaken, the City of Madison Standard Specifications for Public Works Construction, current edition, shall govern the work.

1.3 SUBMITTALS

A. Provide manufacturers product information, for storm sewer materials including pipe, fittings, structure, outfalls, and castings.

B. Provide reports documenting any required testing.

C. Maintain record drawings that show the actual locations, sizes and types of utilities and other features encountered. Record drawings shall be in compliance with specification section 01 78 39 Asbuilt Drawings. Record drawings shall also include digital record site plans generated by the land surveyor contractor.

D. Note any modifications to proposed sewer system size, location or elevation. Record any other deviations from the drawings.

PART 2 - PRODUCTS

2.1 PIPE (GENERAL)

A. Provide the size, type and class/schedule of pipe as indicated on the drawings.

B. Use only pipe supplied from the same manufacturer, and of the same type, unless otherwise specified or approved in advance by the Engineer.

C. When applicable, only pipe, joints, material, and installation approved by Wisconsin Department of Natural Resources and/or the Wisconsin Department of Safety and Professional Services (SPS) for the intended use in the State of Wisconsin shall be used.

2.2 REINFORCED CONCRETE PIPE

A. Pipe and fittings shall conform to ASTM C-76 for circular pipe and ASTM C-507 for elliptical pipe. Unless otherwise specified, provide Class III for circular pipe and Class HE-III for elliptical pipe.

B. Joints for reinforced concrete pipe shall be bell and spigot or tongue and groove. Joints shall be provided with rubber gaskets conforming to ASTM C433. Joints for elliptical pipe shall be provided with trowelable impervious bituminous joint sealer that is manufactured for sealing reinforced concrete sewer pipe joints.

C. When required, external sealing bands shall meet the requirements of ASTM C877 (Type II), and shall be Mar Mac Mac Wrap, or approved equal.

2.3 PVC PIPE (SOLID)

A. Conform to ASTM D-3034 with solvent weld or elastomeric joints. Pipe shall be SDR-26, unless otherwise noted. Pipe over 15 inches in diameter shall meet the requirements of ASTM F679-03.

B. The wall thickness shall conform to requirements for a T-1 wall. PVC material shall have cell classification 12454-B or 12454-C as defined in ASTM D1784 with minimum modules of elasticity of 400,000 psi in tension. The pipe wall shall be homogeneous and contain no seams. Minimum pipe stiffness per ASTM D2412 shall be 60 psi for pipe sizes through 18-inch and 46 psi for 21-inch and larger pipe sizes. Pipe shall withstand impact of 210 foot-pounds for pipe sizes through 8-inch and 220 foot-pounds on larger sizes.

C. Pipe and fittings shall be the product of one manufacturer and the manufacturer shall have experience records substantiating acceptable performance of the pipe to be furnished.

D. Fittings shall be injection molded. Fittings such as saddles, elbows, tees, wyes and others shall be of material and construction corresponding to and have a joint design compatible with the adjacent pipe. Approved adapters shall be provided for transitions to other types of pipe.

E. Joints shall be of the elastomeric type. Elastomeric joints shall be a bell and spigot joint conforming to ASTM D3212 sealed by a rubber gasket conforming to ASTM F477 so that the assembly will remain watertight under all conditions of service, including the movements resulting from the expansion, contraction, settlement and deformation of the pipe. Bells shall be formed integrally with the pipe and shall contain a factory installed positively restrained gasket.

F. All exposed end sections shall be provided with steel apron end walls.

2.4 HDPE PIPE (SOLID WALL AND SLOTTED)

A. Conform to ASTM-D-3350 for PE material with a cell classification of 335434C or better. Pipe shall be thermal butt fusion in accordance with manufacturer's recommendation.

B. Perforates pipe shall be Slotted HDPE pipe; ADS N12 with AASHTO Class I perforations, or approved equal.

2.5 CONNECTIONS FOR DISSIMILAR PIPE MATERIALS

A. Where new sewer connects to and existing dissimilar pipe, the connection shall be made with a no hub type couplings meeting the requirements of CISPI 310. Couplings shall have neoprene gaskets with stainless steel shield, and multiple stainless steel clamps with worm gear tightening device. The couplings shall be made specifically for the type and size of pipe materials being connected. Couplings shall be Fernco RC Strongback.

2.6 ROUND CATCH BASINS

A. Round catch basins shall be 48” (MIN) inside diameter precast concrete unless otherwise shown or required. (See plans for specific sizes.)

B. Submit manufacturer's preproduction (shop) drawings for approval prior to the start of manufacturing.

C. Contractor shall carefully locate all pipe locations, sizes, orientation and elevation prior to ordering catch basin.

D. Round catch basins shall meet the requirements of ASTM C478.

E. Pre-cast catch basin wall thickness shall be minimum of 5”.

F. Provide 8” (min.) thick pre-cast catch basin base. Catch basin bottom section may be pre-cast with integral base.

G. Catch basins shall be provided with precast reinforced concrete in-bell cover designed to accommodate AASHTO H20 loading. In-bell cover shall be provided with 24” opening for casting.

H. Joints

1. Catch basins requiring separate base and riser sections must be provided with standard pipe tongue and groove joints.

2. Seal joints watertight with prefabricated rubber or plastic gaskets or formed in place butyl rubber seal.

3. Joint sealers shall be Kent Seal, ConSeal or approved equal circular o-ring conforming to ASTM C443: Ramnek, Mas-Stik, butyl rubber gasket, or butyl rubber rope.

I. Connections

1. Provide custom knock-outs/cut-outs based on project and location specific conditions.

2. A minimum of 2” of the precast structure is required between the top of a knock-out/cut-out and the top of the structure. A minimum of 2” of precast structure is required between the side of a knock-out/cut-out and the inside face of an adjacent sidewall.

J. Steps

1. Provide steps at 16 inches o.c.± and project approximately 6" from wall.

2. Unless otherwise indicated on the drawings, locate steps over the downstream pipe opening.

3. Steps shall be steel reinforced polypropylene with 1/2-inch diameter deformed reinforcing bar. Steps shall be permanently secured in the catch basin wall. Steps shall be M.A. Industries No. PS1-PF or approved equal.

K. Flowline

1. Provide either pre-cast or cast-in-place flowline that provides positive flow through the structure. Provide bench that directs water towards the flowline.

2. Flowlines and benches shall be formed with gradual, uniform sweeps directed towards the downstream pipe. Provide smooth, troweled finish for flowlines.

L. Adjusting Rings

1. Adjusting rings shall be injection molded high density polyethylene (HDPE), manufactured by Ladtech,IPEX, or equal. Joints shall be sealed with approved silicone or butyl sealant in accordance with manufacturer's recommendations. Materials shall conform to ASTM D-1248 using 100% recycled material. Rings shall be tested to assure compliance in meeting H-20 loading capacity per AASHTO Standards.

2. Where casting adjustment requirements cannot be met by the use of HDPE adjustment rings and upon ENGINEER's approval, CONTRACTOR shall provide precast concrete adjusting rings. Fiber-reinforced pre-cast concrete adjusting rings meeting the requirements of ASTM C-478. Provide rings of 2" or 4" thickness.

3. Precompressed butyl gasket, 3/8"x3 ½" shall be used between the top of the manhole and first adjustment ring, and between all subsequent rings. Butyl material shall be E-Z Stick, or equal.

2.7 CASTINGS

A. All castings shall be heavy duty iron conforming to ASTM A48, Class 20 and rated for AASHTO H-20 loading. Provide non-rocking or machined castings with concealed pickhole.

B. Frames and grates shall be as noted on the plans.

C. Install casting type as indicated on the plans or in the specifications. If the plans and specifications are in conflict, the plans shall govern.

D. Provide butyl sealant material between last adjusting ring and casting base. Adjust casting elevation and slope to match adjacent proposed grades.

PART 3 - EXECUTION

3.1 LAYING PIPE

A. Install all pipes in accordance with ASTM specifications which pertain to the specified type of pipe material and the installation situation.

B. Do not use any pipe or fittings cracked in cutting or handling or otherwise not free from defects.

C. Clean all pipe of any dirt and/or debris both inside and out prior to placing in the trench.

D. Make joints in accordance with manufacturer's directions with due care to avoid damaging pipe and/or disturbing previously laid pipe.

E. Cut pipe only according to manufacturer's directions.

F. Lay all sewer pipes to horizontal alignment and grade shown on the plans with bell ends up hill. Establish and maintain horizontal alignment using total station, transit or theodolite. Use pipe laser or level to establish and maintain grade of pipe. Discrepancies from the required horizontal alignment or grade at any location shall not be greater than 0.10' or 0.05', respectively.

G. Do not exceed specified trench widths.

3.2 BEDDING/INITIAL COVER

A. Provide bedding and initial cover in accordance with the City of Madison Standard Specifications for Public Works Construction, current edition.

B. Storm sewer and sewer services shall be provided with 4" of bedding material and 12" of initial cover material (both measured at the bell of the pipe). Crushed Stone Bedding shall be used for both bedding and initial cover.

3.3 STRUCTURES (INLETS AND CATCH BASINS)

A. Contractor shall determine the proper location, size, elevation, and orientation of all pipes entering new structures before ordering. Do not connect abandoned pipes to new structures. Structures having improper location and/or orientation of the pipe connections will be rejected. Field repairs or adjustments of connection points are not permitted.

B. Limit the excavation for structures so as to provide only the necessary amount of space to sufficiently prepare the subgrade, set the base, set the structure, and lay pipe. Provide a minimum of 1' of clearance between structure and trench wall for adequate backfilling and compaction.

C. Where excavation occurs below the bottom elevation of the structure's base, bring the excavation to the required elevation by the use of compacted crushed stone bedding. A minimum of 8 inches of compacted Crushed Stone Bedding shall be placed below the bottom of the structure base.

D. Set structure base in accordance with elevation and location as indicated on the plans. Install base plumb and level. Install subsequent pre-cast sections in accordance with shop drawing layout. Provide watertight gaskets between each section.

E. Pour inverts with smooth surface draining to downstream pipe. Where two or more lines meet at an angle, provide curved channel. Slope bench or floor at 2 inches/ft towards flow channel.

F. Structures shall be provided with between 4" and 8" of adjusting rings, with the top adjusting ring being 2" thick. Provide butyl sealant material between rings. Once rings are in place, tuck point the exterior joint and provide the entire exterior surface of the adjusting ring riser with a coating of mortar.

3.4 CONNECTIONS TO EXISTING STRUCTURES

A. Make all necessary openings into existing structures or sewers including the reconstruction of existing inverts or benches, as necessary. Patch all openings permanently watertight with concrete brick and mortar, hydraulic cement, or flexible watertight boots.

3.5 ELECTRONIC MARKERS OVER LATERAL

A. Each sanitary lateral shall have a minimum of 2 electronic markers: One shall be located above the wye on the sewer main, and one shall be located above the lateral at the property line. Additional markers shall be placed at each change in horizontal direction. Markers shall be installed per manufacturer's written instruction.

B. The key constraint is the maximum depth of the marker. The signal range of the 3M™ Electronic Marker System (EMS) 4" EXTENDED RANGE 5' BALL MARKER - WASTEWATER (MODEL 1404-XR) is 5 feet.

C. Upon completion, the City will test each electronic marker to confirm that it is installed and functioning properly. If it is determined that the marker has not been installed correctly and/or is not functioning properly, the contractor will be responsible for the all work associated with the installation of a properly functioning marker.

3.6 LEAKAGE TESTING

A. Storm sewers shall be visually inspected for excessive water infiltration and soil leakage into sewers or structures. Contractor shall repair/correct any infiltration or soil leakage that is considered excessive by the Construction Representative.

3.7 SEWER TELEVISING

A. Storm sewers may be videotaped by owner. If video recording reveals a defect that requires repair, the CONTRACTOR shall reimburse the OWNER for the cost of videotaping that section of pipe. All storm sewers with defects, including but not limited to cracked or deformed pipe, misaligned joints, unsealed lift holes, and incorrect gradelines, as identified through videotaping, shall be re-laid or shall be paid for at 50% of the price bid. Relaying the pipe or reducing payment shall be at OWNER's discretion.

3.8 ABANDONMENT OF EXISTING STORM SEWER FACILITIES

A. Where indicated on the plans, existing sewer to be left in place shall be abandoned in accordance with the City of Madison Standard Specifications for Public Works Construction. Sewer shall not be abandoned until existing services have been reconnected to the replacement sewer. Abandoning sewers is considered incidental to the construction.

B. In paved areas or current/future building pad areas, existing storm sewer facilities are required to be abandoned as follows:

1. Remove existing pipes or fill them with sand or grout and seal ends with a minimum 2-foot thick grout plug.

2. Remove existing inlets, catch basins, and manholes to at least 4 feet below finished grade. Provide a minimum 6-inch hole in the bottom of the structure and fill the remaining portion with bedding stone.

END OF SECTION