

# LEWES PARK & RIDE AND SITE WORK

SUSSEX COUNTY

CONTRACT NO. T200612502

FEDERAL AID PROJECT NO. DE-04-0003

10.28.2015

## FINAL TECHNICAL SPECIFICATIONS



DESCRIPTION / TYPE	LENGTH	NO.	DESCRIPTION / TYPE	LENGTH	NO.
CONC. SIDEWALK					

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## SECTION 014000 - QUALITY REQUIREMENTS

### PART 1 GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
1. Regulatory requirements that supplement and add to the regulatory requirements stipulated in the Agreement and General Conditions.
  2. Requirements for Quality Assurance (QA) and Quality Control (QC) program activities to be performed during the Contract including quality requirements for the following:
    - a. Management responsibility.
    - b. A documented quality management system.
    - c. Design control.
    - d. Document control.
    - e. Purchasing, including requirements for Supplier quality assurance.
    - f. Product identification and traceability.
    - g. Process control.
    - h. Inspection and testing.
    - i. Inspection, measuring, and test equipment.
    - j. Inspection and test status.
    - k. Nonconformance reporting.
    - l. Corrective action procedures.
    - m. Quality records, including logs, reports, and forms.
    - n. Quality Audits.
    - o. Training.
  3. Requirement for a Contractor's Quality Assurance Plan (CQAP).
  4. Requirements and qualifications for an independent certified Testing and Inspection Agency and an Approved Agency required by the ICC International Building Code.
  5. Requirements for an Inspection and Test Plan.
  6. Quality requirements for inspection and test procedures, control of measuring and test equipment, and tracking inspection and test status.

#### 1.2 REFERENCES

- A. American Society for Testing and Materials (ASTM):
1. ASTM E 329, Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction.
- B. International Code Council (ICC):
1. ICC International Building Code 2012 (IBC).
- C. U. S. Government:
1. Code of Federal Regulations (CFR):

- a. 29 CFR 1910, Department of Labor, Occupational Safety and Health Administration (OSHA), Part 1910 Occupational Safety and Health Standards.
- b. 29 CFR 1926, Department of Labor, Occupational Safety and Health Administration (OSHA), Part 1926 Safety and Health Regulations for Construction.
2. United States Code (USC):
  - a. 49 USC 601, Department of Transportation, Pipelines, Safety.
    - 1) Amendment of Title 49, United States Code (H.R. 5782), Pipeline Inspection, Protection, Enforcement, and Safety Act of 2006.
3. Federal Transit Administration (FTA):
  - a. FTA IT-90-5001-02.1, Quality Assurance and Quality Control Guidelines.

### 1.3 PERFORMANCE REQUIREMENTS

- A. Quality Control (QC) Program:
  1. The Contractor is responsible for all quality control for this Contract, with the exception of those tests or inspections specifically identified as being performed by others.
  2. Omissions and errors in the Contract Document descriptions do not relieve the Contractor of his responsibility to perform the tests/inspections required within the scope of this Contract.
  3. Inspections and tests performed by the Engineer are for the Owner's Quality Assurance and do not relieve the Contractor from the responsibility of meeting the specified requirements.
    - a. Inspections and tests performed by the Engineer are not to be considered a guarantee for acceptance of materials that will be delivered subsequent to the time the items were inspected or tested.
- B. Quality Assurance (QA) Program:
  1. Before starting the other Work of this Contract, develop and implement an approved Contractor's Quality Assurance Plan (CQAP) for this Contract that incorporates the requirements of the Federal Transportation Administration's 15 quality elements as described in FTA IT-90-5001-02.1, referred to as the FTA Guidelines, and the additional requirements in this Contract's Specifications.
    - a. The CQAP must include the specified requirements of all 15 quality elements listed in the FTA Guidelines.
    - b. Submit the Contractor's Quality Assurance Plan (CQAP) to the Engineer for approval.
- C. Contractor Quality Assurance Plan (CQAP):
  1. Management Responsibility :
    - a. Define your organizations quality policy in the CQAP.

- 1) Provide a statement that shows your organization's commitment to the quality policy extends to the highest level.
    - a) Your organization's management must declare and document its commitment to quality within a Quality Policy Statement to be included at the beginning of the CQAP.
  - 2) In the CQAP, show how your quality policy extends to all levels of your organization.
- b. Within 15 days of the Notice to Proceed, submit to the Engineer a list that identifies all of the Contractor's principal staff assignments and consultants, and that lists their addresses and other contact information.
- c. Contractor's Principal Construction Staff:
- 1) Contractor's Superintendent:
    - a) Employ a superintendent with the qualifications specified in Subparagraph 1.05.A.2 and who is empowered to represent and to act for the Contractor.
  - 2) Contractor's Safety Representative:
    - a) Designate a member of the Contractor's full-time on-site construction staff who has the qualifications specified in Subparagraph 1.05.A.4 to be the Contractor's Safety Representative, and submit his or her resume showing his or her qualifications and experience to the Engineer for approval.
    - b) Empower the Contractor's Safety Representative with the responsibility for supervising the safety of persons on or about the Work and the property affected by these persons as stipulated in Contract Documents; and direct the Contractor's Safety Representative to report and submit required paperwork relating to on-the-job injuries to the Engineer within 24 hours of the incident causing the injury.
    - c) The Contractor may not replace the approved Contractor's Safety Representative without written permission from the Engineer.
- d. Quality Assurance and Control Personnel:
- 1) Identify those persons responsible for the quality assurance and control functions in the CQAP; and define in writing the responsibility, authority, and interrelation of those persons.
    - a) Include an Organization Chart detailing the quality assurance and control organization and reporting responsibilities.

- b) Identify a Contractor Quality Assurance Manager, and show that his position is independent of the Contract's construction staff.
  - c) Show the Contractor Quality Assurance Manager's staff, and clear lines of authority and responsibility for quality management.
- 2) Place the Quality Assurance Manager and other assigned quality assurance personnel on the Contractor's direct payroll, but do not assign them to any other positions under this Contract.
- a) Have the Quality Assurance Manager report directly to the highest level of the Contractor's management, such as the corporate principal or corporate quality assurance manager, and not to any project level manager.
    - (1) Set up the Contractor Quality Assurance Manager position to be independent of the Contract's construction staff.
- 3) Contractor Quality Assurance Manager:
- a) Employ a Contractor Quality Assurance Manager with the qualifications specified in Subparagraph 1.05.A.3 and empowered with full authority and responsibility to represent and act for the Contractor on all quality related matters for this Contract.
    - (1) Give the Quality Assurance Manager the authority and responsibility for ensuring that the quality policy is communicated, implemented, and maintained.
    - (2) At all times that any work is in progress, insure that the Quality Assurance Manager, or his designated substitute, is on the Site and available.
    - (3) Delegate responsibility for coordinating inspections and testing to be performed by the Testing and Inspecting Agencies to the Quality Assurance Manager, and empower the Quality Assurance Manager with the authority to stop further construction of non-conforming Work pending completion of required corrective action.
- 4) Quality Control Inspectors and Test Personnel:
- a) Employ, at a minimum, one qualified full-time Quality Control inspector to be on-site during the installation and testing phase of the Contract.

- b) Assign or designate additional Contractor Quality Control personnel to perform inspections and test the Work as required.
    - c) Submit resumes showing the names, qualifications, and experience of all quality control personnel that are assigned to the Quality Control Manager to the Engineer for approval.
  - 5) Do not remove any Contractor quality assurance personnel from their duties on this Contract without prior written notice to the Engineer.
    - a) If the Contractor plans to remove or replace the Quality Assurance Manager or other key quality control personnel identified on the organization chart, the Contractor must notify the Engineer in writing before replacing these personnel.
    - b) Submit the resumes of replacements for the Quality Assurance Manager and other key quality control personnel showing their qualifications to the Engineer for approval.
- 2. Documented Quality Management System:
  - a. Establish and document a quality management system within the Contractor Quality Assurance Plan (CQAP) to ensure that Contract quality objectives are satisfied, and maintain the quality management system during the life of the Contract.
    - 1) Develop, implement, and maintain a quality management system consistent with the requirements of this Section; and FTA-IT-90-5001-02.1 to assure that the equipment and materials provided conform to the applicable requirements of every Section of the Contract Specifications.
    - 2) Provide a quality management system to assure accuracy and consistency in production, installation, and construction processes by providing documented work instructions where needed to ensure quality.
    - 3) Do not begin Work covered by the Contractor's Quality Assurance Plan (CQAP) until the Engineer reviews and approves the plan.
    - 4) Extend the quality management system requirements to Suppliers and Subcontractors as appropriate.
  - b. Establish, implement, and maintain a Quality Procedure Development Plan (QPDP) to develop procedures and instructions for implementing the Contractor's Quality Assurance Plan (CQAP).
    - 1) Develop written procedures and instructions for activities affecting quality in design, procurement, manufacturing, and construction activities as applicable to the Work being performed under this Contract.

- a) Each procedure must contain a statement giving its purpose, scope, applicability, and assigned responsibilities.
  - (1) Assign specific responsibilities, and clearly delineate individual job authorities and responsibilities.
- b) Describe sequential processes to be followed to accomplish quality objectives; and contain references to codes, standards, specifications, and related or interfacing procedures.
  - (1) Prescribe inspection and testing techniques with written procedures, and keep them up-to-date.
  - (2) If new inspection or testing techniques are being used for construction or manufacturing, allow adequate time to develop appropriate quality procedures for the new techniques.
  - (3) Include formats for the quality records needed to ensure that the procedures and instructions are followed and that documentation requirements are understood.
- c) In developing the quality procedures, give consideration to identifying and acquiring any inspection equipment, skills, or special quality processes needed to ensure quality performance.
  - 2) Include an index of all procedures and instructions to provide a comprehensive account of the quality controls that are required to implement the Contractor Quality Assurance Plan (CQAP).
- c. Daily Quality Management Reports:
  - 1) Prepare Daily Quality Management Reports for each day any Work is performed and which at a minimum identify material deliveries, Work accomplished, tests conducted, results of inspection and tests, nonconforming work and its disposition, causes of nonconforming work, and corrective actions taken to prevent the recurrence of similar nonconforming work.
  - 2) Submit the Daily Quality Management Reports to the Engineer for review on a daily basis.
- d. Certification of Payment Requests:
  - 1) Submit each Application for Payments in accordance with the requirements of Division 100 General Provisions.
- e. Certification of Completion of the Work:

- 1) When all obligations under the Contract have been fulfilled, submit written notice to the Engineer in accordance with the requirements of Division 100 General Provisions.
3. Design Control:
- a. Establish appropriate written procedures within the Contractor's Quality Assurance Plan (CQAP) for identifying, documenting, and reviewing and approving all changes and modifications to the original design.
    - 1) Establish and maintain procedures to control and verify the design of systems in order to ensure that the design criteria, other specified requirements, and requirements of the relevant regulatory agencies are met.
    - 2) Extend this responsibility to those responsible for developing "as-built" documents as part of the design documentation at the end of the Contract, and to construction or manufacturing to ensure compliance with the design requirements.
  - b. Plan the design interfaces and design verification activities to ensure that the design requirements are understood, and control design changes through Contract completion.
    - 1) Prepare a Design Plan that identifies the individuals responsible for different design parts and who has the responsibility to assure the quality of the design.
      - a) Identify, document, and review design input requirements; and have the requirements reviewed by the designer and those responsible for developing the requirements.
      - b) Assign competent individuals to verify the quality of the design.
    - 2) Verify and document that the design output complies with the design input requirements.
      - a) Design output includes acceptance criteria, conformance to regulatory requirements whether or not these have been stated in the design output requirements, and identifying those aspects of the design that are crucial to the safe and proper functioning of the final product or system.
      - b) Identify the various organizational interfaces required between various groups producing and commenting on the design, and specify the information to be documented, transmitted, and regularly reviewed.
      - c) Perform the following design verification activities, as appropriate:
        - (1) Alternative calculations.

- (2) Independent checks of design calculations, specifications, drawings, and Contract Documents.
    - (3) Conducting and documenting design reviews.
    - (4) Undertaking qualification tests and demonstrations.
    - (5) Comparing the design with similar proven designs, if available.
    - (6) Design reviews for constructability, operability, and maintainability.
  - 3) Specify within the Design Plan how the operating and maintenance departments of the Owner would interface with those producing the design.
4. Document Control:
  - a. Establish and maintain written procedures for the control of Contract documents, and record these procedures within the Contractor's Quality Assurance Plan (CQAP).
    - 1) Develop document control procedures that provide controls for the drawings, specifications, Contract data, special work instructions, operational procedures, and receipt and transmittal of submittals.
    - 2) Provide procedures for the distribution and storage of documents related to the Contract.
      - a) Promptly eliminate obsolete documents from each work location.
      - b) Retain superseded documents in Contract files, and clearly identify each as such.
    - 3) Examples of the types of Contract documents requiring control include, but are not limited to:
      - a) Contract Drawings.
      - b) Specifications.
      - c) Special work instructions.
      - d) Operational procedures.
      - e) Quality assurance program procedures.
  - b. Develop document control measures to assure that all relevant documents are current and available to all users who require them.
    - 1) Develop procedures to insure that documents are reviewed by the relevant authorized personnel.
      - a) Provide procedures to insure that changes to documents are reviewed and approved by the same authorized individuals that reviewed and approved the original documents.
      - b) Control changes to Contract documents, and promptly distribute those changes to all required

- locations together with a master list enumerating the current revisions of each document.
- 2) Develop procedures to assure that all documents required are received and distributed in a timely manner, and contain the necessary technical information.
    - a) Distribute and make available copies of documents to all locations needing them to assure that the quality management system functions effectively.
5. Purchasing:
- a. Establish and maintain procedures to assure that purchased services and products conform to specified requirements.
  - b. Provide written procedures within the Contractor's Quality Assurance Plan (CQAP) that address at a minimum the following:
    - 1) Evaluation and selection of Suppliers using specified evaluation criteria including supplier quality programs.
      - a) Generate a list of qualified Suppliers with the descriptions of the scope of services that they have been qualified to provide for the Contract.
        - (1) Prior to procurement of items and materials, submit to the Engineer a list of Suppliers and Subcontractors that includes a description of the items to be supplied, and/or other pertinent information, as appropriate, for approval.
      - b) Select Suppliers based on their ability to meet Contract requirements.
    - 2) Transmission of applicable design, manufacturing, quality, and other associated technical requirements in purchase documents.
    - 3) Review and approval of purchasing documents by a designated authority to verify the adequacy of the requirements specified prior to release.
    - 4) Periodic assessment of Supplier performance; e.g., inspection and testing at the source, and/or auditing of the Supplier by the Contractor.
    - 5) Evaluation of the adequacy of the products procured at the time of receipt and/or at the point of manufacture to verify compliance with purchasing documents.
  - c. Extend the quality requirements of this Section to Suppliers and Subcontractors as appropriate to the work being performed.
    - 1) Within procurement documents, impose the same quality control requirements upon Suppliers and Subcontractors, including inspection and test procedures, as imposed on the Contractor by this Section, other Contract Specifications, and referenced standards.

6. Product Identification and Traceability:
  - a. Establish and maintain measures for identifying and controlling items of production such as batches, materials, parts, and components, to prevent the use of incorrect or defective items, and to assure that only correct and acceptable items are used or installed.
    - 1) Develop documented procedures within the Contractors' Quality Assurance Plan (CQAP) to assure that procured items, equipment, and materials are physically identified.
      - a) Insure that items are traceable to required documents during all phases of production from receipt of raw materials, components, or subassemblies through the construction process, to delivery of final products.
        - (1) Insure identification and traceability of items throughout all inspections, test activities, and record keeping.
        - (2) Develop and maintain a documented system to clearly identify the inspection and test status of materials and equipment throughout construction.
        - (3) For stored items, preserve each item's identification and traceability consistent with the expected duration and type of storage.
      - b) Physically identify and control items to the extent possible from the time of receipt inspection through installation and testing.
        - (1) Insure the identity of items by placing markings on or with the items, or by placing the items in specifically identified physical locations.
          - (a) Facilitate identification by means of stamps, tags, or other control devices attached to or accompanying the material or equipment.
          - (b) Employ physical separation, procedural control, or other appropriate means where physical identification is impractical.
        - (2) Mark, track, and control equipment and materials that require inspection or testing within specific time intervals.
        - (3) Establish procedures to control the use of status tags, including logging, installation, and removal.

- (4) Define who is authorized to apply and remove status tags.
  - 2) Serialization Plans:
    - a) Develop a comprehensive plan for tracking the serial numbers of equipment provided under this Contract.
      - (1) Include the proposed numbering scheme, method for assigning numbers, and tracking tools and procedures.
      - (2) Include the proposed organization of the serial number database.
    - b) Maintain the serial number database and use it to track inventory and to establish equipment reliability.
  - 3) Intentional unauthorized removal of non-conformance status tags will result in immediate dismissal and removal from the Work Site of all personnel responsible for the unauthorized removal.
  - 4) Segregate items that do not have identification, items for which record traceability has been lost, and items that do not conform to the requirements of the Contract to prevent their inadvertent incorporation into the Work of this Contract.
- b. Establish and maintain procedures for receiving incoming products, and for final inspection and testing.
  - 1) Specify and implement the procedures for receiving incoming products and for final inspection and testing, and document the results of these procedures.
    - a) Conform with the requirements specified in Division 100, General Provisions, and establish material control procedures to ensure that equipment and materials accepted through receiving inspection comply with the procurement documents, and to assure that equipment and materials are properly received, inspected, stored, maintained, installed, and used.
  - 2) Receiving Inspection:
    - a) Implement documented receiving inspection procedures for purchased items such as materials, parts, or equipment delivered to the Contractor.
    - b) Receiving Inspection Records:
      - (1) Develop and maintain Receiving Inspection Records, which at a minimum must include a Receiving Inspection Log containing the following information for each item received:
        - (a) Purchase order number.
        - (b) Item number.

- (c) Supplier name.
- (d) Quantity.
- (e) Item description.
- (f) Reference to applicable Contract requirements.
- (g) Date received.
- (h) Heat number, serial number, or other identification, as applicable.
- (i) Inspection records for in-transit damage and gross defects.
- (j) Verification of receipt of all required supporting documentation, including Certificates of Compliance and Certified Material Test Reports, and verification that these documents are traceable to the items received.
- (k) Acceptability (accept/reject) and nonconformance report number, if applicable.
- (l) Quality control person's signature and date.

7. Process Control:

- a. Identify and plan the production and installation processes that directly affect quality, and ensure these processes are performed under controlled conditions.
  - 1) Handle, store, and preserve procured items, equipment, and materials from the time of receipt to the time of installation and testing to prevent damage, deterioration, distortion of shape or dimension, loss, degradation, loss of identification, or substitution.
  - 2) Use special devices, e.g., crates, boxes, containers, dividers, slings, material handling and transportation equipment, and other facilities, for handling material; and insure that these special devices are maintained and periodically inspected.
  - 3) Provide only new materials for incorporation into the Work except where specified otherwise.
  - 4) Develop work instructions for production and installation processes that include:
    - a) Sequencing work operations where the work is complex or when there are multi-discipline interfaces, including hold and witness points for required examinations, inspections, and tests.
      - (1) Hold points are mandatory.
      - (2) Witness points may be waived by the establishing individual.

- b) Using suitable equipment.
  - c) Providing a suitable work environment.
  - d) Using qualified personnel, and stating qualification requirements, e.g. certifications, credentials, or licenses.
  - e) Conforming to referenced and other applicable codes, standards, and quality plans.
  - f) Controlling and monitoring work processes during manufacturing, installation, and construction.
- b. Continuously monitor special processes, the result of which cannot be verified by subsequent inspection and testing.
- 1) Conduct continuous monitoring and/or assure conformance with documented procedures during special processes such as welding, nondestructive examination, and heat treatment where the results cannot be verified during subsequent work operations.
  - 2) Use personnel approved by the Engineer and that have the experience, training, certification, and where required the license commensurate with the scope, complexity, or nature of the activity whenever performing special processes, i.e., welding, brazing; or inspection/test tasks.
  - 3) Special process procedures at a minimum must include the following.
    - a) Requirements for the qualification of special process procedures.
    - b) Personnel qualifications required for performing the special process including certifications, credentials, or licenses.
    - c) Orientation into the quality program requirements.
    - d) Training in the applicable special process procedures.
    - e) Evaluation (initial and periodic) of the personnel performing special processes.
8. Inspection and Testing:
- a. Testing and Inspection Agencies:
    - 1) Employ the services of one or more independent certified material testing laboratories, hereafter referred to as the Testing and Inspection Agency or Testing and Inspection Agencies, having the qualifications specified in Subparagraph 1.04.A.1 to perform materials testing, control testing, and inspections of the materials to be incorporated into the Work of this Contract.
      - a) The Testing and Inspection Agencies retained by the Contractor will not be responsible for performing

- the special inspections required by the ICC International Building Code.
- 2) Dismissal and replacement of any of these independent certified Testing and Inspection Agencies by the Contractor requires written notice to and the approval from the Engineer.
- b. Code-Required Approved Agency for Performing Special Inspections:
- 1) To perform the special inspections required by the ICC International Building Code (IBC) which are listed for convenience in Section 01453, Code-Required Special Inspections and Procedures, the Owner or Engineer acting as the Owner's agent will employ an independent Approved Agency, as defined in the Code, that has the following qualifications:
    - a) Established, recognized, and regularly engaged in conducting tests or furnishing inspection services.
    - b) Demonstrating competence to the satisfaction of the building official having jurisdiction over the Work of the Contract.
    - c) Conforming to the quality standards for testing laboratories of the nationally recognized associations and agencies that promulgate the test standards specified, particularly to the requirements of ASTM E 329 and the standards referenced in other Sections of this Contract.
    - d) Capable of performing the reviews, inspections, and testing required by this Contract.
- c. Inspection, Sampling, and Testing:
- 1) For the duration of this Contract, materials and fabrication procedures will be subject to inspection, sampling, and testing in the mill, shop, and field by the Engineer, the building official, the Testing and Inspection Agency or Agencies, and by the code-required Approved Agency for performing special inspections.
    - a) The Engineer and/or the code-required Approved Agency may elect to perform inspections and/or tests of materials at the place of manufacture, the shipping point, or at the destination to verify compliance with applicable Specification requirements.
    - b) Inspection and tests, conducted by persons or agencies other than the Contractor, do not in any way relieve the Contractor of responsibility for providing materials and fabrication procedures in

- compliance with specified requirements and for meeting the requirements of all Specifications and the referenced standards.
- 2) When material furnished or work performed by the Contractor fails to conform to the Contract Documents, the Testing and Inspection Agency or the code-required Approved Agency for performing special inspections, whichever was responsible for performing the testing or inspection revealing the nonconformance of the materials or work, is responsible for immediately reporting such deficiency to the Engineer and the Contractor.
  - 3) The Testing and Inspection Agency and the code-required Approved Agency for performing special inspections must submit certified written reports that document the results of all tests and inspections performed directly to the Engineer immediately after the work is performed.
    - a) The reports must state whether the tested and inspected items comply with specified requirements or deviate from them.
- d. Inspection and Test Plan:
- 1) Develop an Inspection and Test Plan, consistent with the requirements of this Section, to plan inspection and testing procedures as necessary to verify the quality of the Work of this Contract.
    - a) Identify all required inspections and tests required by each Specification Section, the required frequency of each, the accept/reject criteria of each, records required to document compliance, and the procedures or instruction to be used for control of each activity.
    - b) Provide sufficient detail to allow the Engineer, or any agency having jurisdictional authority over the Work, to find the operations to be inspected by that organization in the plan.
    - c) Provide written inspection and test procedures that address at a minimum the following:
      - (1) Test prerequisites.
      - (2) Required tools, equipment, and instrumentation.
      - (3) Personnel qualification requirements.
      - (4) Necessary environmental conditions.
      - (5) Acceptance criteria.
      - (6) Nonconformance reporting requirements.
      - (7) Data to be recorded.
      - (8) Test Results reporting forms.

- (9) Identification of items inspected or tested.
- 2) Submit the Inspection and Test Plan to the Engineer for approval, and do not commence inspection or test activities until the Engineer's approval is granted.
- 3) Implement and maintain the approved Inspection and Test Plan for the duration of this Contract.
  - a) Using the Contractor's quality control personnel or an approved Testing and Inspecting Agency as appropriate, perform in-process testing and inspection in accordance with the documented procedures reviewed and approved by the Engineer to verify conformance of each item or work activity to specified requirements.
    - (1) Make procedures and instructions readily available to inspection and test personnel at the time and place of the inspection or test.
    - (2) Perform acceptance testing and inspection using qualified personnel other than those performing the Work being tested or inspected.
    - (3) When methods of inspection and/or testing are changed, reflect the revisions in methodology in approved written procedures prior to implementing the change on any Work.
    - (4) Immediately report inspection/test results indicating nonconformance with specified requirements (failure) to the Engineer.
  - b) Perform both inspections and process monitoring to ensure that the requirements specified for controlling work processes and the quality of the item are being achieved.
    - (1) Verify that the methods and processes reflected in approved work procedures and instructions are completely and continuously followed.
    - (2) Perform inspections and tests as necessary to verify the quality of the Work on items such as the following:
      - (a) Items of the Work affecting safety.
      - (b) Items that affect system reliability.
      - (c) Items that affect service life.
      - (d) Long lead-time items and custom manufactured items.
      - (e) Items in high visibility areas.

- (f) ADA compliance items.
    - c) Prepare and submit records (reports) of inspection and test activities that address at a minimum the following:
      - (1) Name of the item(s) inspected/tested.
      - (2) Specification reference by Section and Paragraph, and where applicable revision level or revision date.
      - (3) Quantity of items.
      - (4) Location of the item(s).
      - (5) Inspection/test procedure reference.
      - (6) Date of inspection or test activities.
      - (7) Name of the inspector/tester.
      - (8) Observations/comments of the inspector/tester.
      - (9) Specified requirements referenced to the appropriate Specification Section/Paragraph number.
      - (10) Deviations/non-conformances.
      - (11) Corrective action.
      - (12) Evaluation of results.
      - (13) Acceptability.
      - (14) Signature of authorized inspection and test personnel.
  - e. Certificates of Compliance and Certified Material Test Reports:
    - 1) Materials may be accepted by the Engineer on the basis of a Certificate of Compliance or Certified Material Test Report.
    - 2) Materials accepted on the basis of a Certificate of Compliance may be sampled and inspected/tested by the Engineer, or his designee, at any time.
    - 3) The fact that the materials were accepted on the basis of certification does not relieve the Contractor of his responsibility to provide materials and equipment that comply with the Specifications.
    - 4) Submit the Certificate of Compliance/Certified Material Test Report to the Engineer prior to incorporation of the item into the Work.
  - f. Refer to Division 100, General Provisions, for additional testing and inspection requirements.
- 9. Inspection, Measuring, and Test Equipment (M&TE) :
  - a. Identify, control, calibrate, and maintain inspection, measuring, and test equipment (M&TE) required to perform inspections, tests, and measurements in order to demonstrate conformance of Work to the specified requirements.

- 1) Establish and maintain a system to identify, control, calibrate, and maintain all inspection, measuring, and test equipment prior to its use to demonstrate that construction conforms to the requirements of the Contract Documents.
  - a) Identify each piece of inspection, measuring, and test equipment with a unique identification label permanently and directly affixed to the equipment.
  - b) Affix calibration labels to inspection, measuring, and test equipment that show the date the equipment was last calibrated and the date recalibration is due.
- 2) Use only inspection, measuring, and test equipment of the proper type and accuracy for the required measurement, and store and use equipment under suitable environmental conditions.
  - a) Inspections or tests performed using inspection, measuring, and test equipment that is subsequently found to be out-of-tolerance, or that is damaged during use, or that is lost are considered nonconforming until all characteristics previously inspected or tested using the equipment have been reassessed and re-verified as correct, re-inspected, or re-tested as necessary.
    - (1) A nonconformance report for out-of-tolerance or damaged inspection, measuring, and test equipment must be processed in accordance with the requirements of Nonconformance Reporting as specified in Subparagraph 1.03.C.11.
- b. Make provisions for the recalibration of inspection, measuring, and test equipment in a timely manner.
  - 1) Either the Contractor or an agency/vendor must perform and document the calibration of inspection, measuring, and test equipment using calibration standards traceable to the National Institute of Standards and Technology (NIST), and the calibrations must be performed at the intervals specified in the calibration procedures to assure the accuracy of inspection, measuring, and test equipment.
    - a) NIST information is accessible at [ts.nist.gov](http://ts.nist.gov).
  - 2) In the event that no national standards exist for the calibration of an item of inspection, measuring, and test equipment, document the basis used for the calibration of the item.
  - 3) Recall and recalibrate inspection, measuring, and test equipment at pre-prescribed intervals, and maintain records of calibration performed.

10. Inspection and Test Status:
  - a. Provide a means for identifying the inspection and test status of work during its production and installation.
    - 1) Maintain the inspection and test status of the work by means of marking, stamps, tags, labels, routing cards, inspection records, test software, physical location, or other suitable means.
    - 2) Status identification must indicate the conformance or nonconformance of each item with regard to inspections and tests performed.
  - b. Establish controls to assure that only work that has passed the required inspections and tests are accepted.
    - 1) Prepare Daily Quality Control Reports for each day that Work is performed, and which at a minimum identify the tests conducted and the results of inspections and tests.
      - a) Record the status of completed, tested, and inspected items or construction work in Daily Quality Control Reports.
      - b) Submit the Daily Quality Control Reports to the Engineer in a timely manner for information.
    - 2) Document nonconforming items or construction work in nonconformance reports that are issued in accordance with the requirements for nonconformance reporting specified in Subparagraph 1.03.C.11.
11. Nonconformance Reporting:
  - a. A nonconformance exists when material furnished or work performed does not comply with the requirements of the Contract Drawings, Specifications, codes, standards, or any other Contract requirements; and such nonconforming work is therefore considered defective.
    - 1) Nonconforming work also exists when either material or equipment exhibits a deficiency in physical inspection, test characteristics, or documentation.
  - b. Establish and maintain documented procedures to identify and control nonconforming work in order to ensure that only conforming Work is used for construction.
    - 1) Establish written procedures to define the methods and responsibilities for the identification, documentation, control, and processing of nonconforming equipment and material.
    - 2) Apply this system for identifying and controlling nonconforming work to the actions associated with installation and construction, and to all material and equipment that, for any reason, fails to conform to the

Specifications or other applicable and approved product descriptions.

- a) Develop a mode of operation that emphasizes the identification, correction, and prevention of nonconforming work.
  - 3) The Contractor quality control personnel have the authority to stop that portion of the work that does not comply with the Contract requirements.
- c. Nonconformance Procedure:
- 1) Comply with the requirements regarding nonconforming and defective work in Division 100, General Provisions, and with the requirements for nonconforming Work specified in this Section.
  - 2) To identify and prevent the use of nonconforming items/materials, develop nonconformance procedures that address and include the following:
    - a) Definition of “nonconformance”.
    - b) Methods of identifying non-conformances.
    - c) Nonconformance reporting requirements that include immediate verbal notification to the Engineer followed by submission of a written Nonconformance Report to the Engineer.
    - d) Application and removal of nonconformance status tags.
    - e) Evaluations/recommendations.
    - f) Physical segregation, removal from the Site, or reassignment of nonconforming items to lesser applications.
      - (1) Nonconformance items to be reassigned to lesser applications must be previously approved for the new application by the Engineer.
    - g) Cause of non-conformance.
    - h) Corrective action to be taken.
  - 3) Nonconformance Report Log:
    - a) Develop, maintain, and periodically submit a Nonconformance Report Log to the Engineer that contains the following information, at a minimum, to enable tracking of all Nonconformance Reports:
      - (1) Sequential, unique nonconformance report number.
      - (2) Date issued.
      - (3) Originator.
      - (4) System affected/drawing number/serial number.

- (5) Brief description of the nonconformance and its source (e.g. Supplier, Subcontractor, welder).
  - (6) Recommended and approved disposition.
  - (7) Verification of corrective action.
  - (8) Date closed.
  - (9) Contractor Quality Control Manager's initials.
  - (10) Remarks, as applicable.
- b) The disposition of all Nonconformance Reports must conform to the requirements of the required corrective action as specified in Subparagraph 1.03.C.12.
12. Corrective Action :
- a. The resolution of nonconforming item/material issues must be approved by the Engineer with input from the Contractor's project management and quality assurance personnel.
    - 1) Assign corrective action dispositions to Nonconformance Reports as follows:
      - a) REPAIR – Nonconforming items or work that are restored to a conforming condition by alternative means.
      - b) REWORK – Nonconforming items or work that are restored through additional normal processing.
      - c) USE-AS-IS – Nonconforming items or work that are to be used in its current condition.
      - d) SCRAP – Nonconforming items that do not meet requirements and cannot be practically assigned REWORK or REPAIR dispositions to meet requirements.
    - 2) Re-inspect items having Nonconformance Reports assigned either a REPAIR or REWORK disposition in accordance with the original requirements.
    - 3) Submit Nonconformance Reports with dispositions of REPAIR or USE-AS-IS to the Engineer for approval prior to the implementation of corrective action.
      - a) The Owner may seek compensation for items assigned either a REPAIR or USE-AS-IS disposition.
    - 4) Immediately segregate items assigned a SCRAP disposition from conforming material, and remove them from the Site within 24 hours of assigning a SCRAP disposition, as practicable.

- b. Establish and maintain written procedures of investigating the cause of nonconforming work and for the corrective action needed to prevent recurrence of nonconforming work.
  - 1) Investigate the root cause of nonconforming conditions and take the corrective actions needed to prevent recurrence.
  - 2) Ensure that corrective actions are completed in a timely fashion and that they are effective.
  - 3) Provide measures for analyzing processes to detect and eliminate potential causes of nonconforming work.
  - 4) Initiate preventative actions to deal with problems at a level corresponding to the risks encountered.
  - 5) Include measures for implementing and recording changes in procedures resulting from corrective action.
- 13. Quality Records:
  - a. Establish and maintain written procedures for quality records to identify which records are to be kept; responsibility for their production and collection; and responsibility for indexing, filing, storage, maintenance, and disposition of quality records.
    - 1) Identify every type of quality record to be generated as a result of implementing the CQAP, and specify the retention time for each.
    - 2) Quality records requiring control include, but are not limited to:
      - a) Inspection Reports.
      - b) Test Data.
      - c) Certification Records.
      - d) Personnel Qualifications.
      - e) Submittals, Value Engineering Change Proposals (VECP), Change Orders, and Requests for Interpretation/Information (RFI).
      - f) Calibration Records.
      - g) Nonconformance Reports.
      - h) Corrective Action Reports.
      - i) Quality Audit Reports.
    - 3) Include Supplier, Contractor, and Subcontractor quality records.
    - 4) Ensure that a level of authority commensurate with the nature of the quality records verifies the adequacy of records on a systematic basis.
  - b. Index, file, and maintain all quality records in a manner that provides for timely retrieval, traceability to, identification with, and acceptability of, material, equipment and systems.
    - 1) Quality records must be legible and specify the work involved.

- 2) Only complete, legible, and properly authenticated documents can be considered quality records.
  - 3) Maintain quality records to provide objective evidence that all activities conform to the CQAP requirements specified, to show that the quality management system is properly functioning, and to document the basis of decisions.
  - 4) Maintain quality records in a manner that minimizes deterioration and damage.
  - 5) Index of Quality Control Records:
    - a) Prepare and submit an index of all quality control records that will be accumulated and maintained during the progress of the Work.
  - c. Make quality records available to the Engineer upon request.
  - d. Retention time for all quality records will be not less than 3 years after the date of Final Acceptance, except as modified below.
    - 1) Sample retention:
      - a) Retain all Samples of materials, products, or assemblies to be incorporated into the Work for a minimum period of 1 year after the date of the Certificate of Final Acceptance.
    - 2) Provide 30 days notice to the Engineer of intent to discard or destroy quality records, including Samples as may be in the possession of the Contractor or his Subcontractors, subsequent to this retention time.
14. Quality Audits:
- a. Establish and implement written procedures for the performance of internal quality audits to assure that the elements of the quality management system are functioning as intended.
    - 1) Quality audits are not the same as financial audits.
  - b. Quality Audit Schedule:
    - 1) Establish a Quality Audit Schedule denoting the locations, organizations to be audited, topics, and scheduled dates.
    - 2) Schedule audits based upon the status and importance of the activity being audited.
      - a) At a minimum, perform audits at 90-day intervals or as necessary to verify that all elements of the Quality Management System are functioning as intended.
    - 3) Update the audit schedule at 90-day intervals beginning on the date of approval of the initial schedule by the Engineer.
  - c. Quality Audit Plan:
    - 1) Prepare and submit quality audit plans to the Engineer for each audit.
      - a) Address the audit scope, location, and dates.
      - b) Include the audit checklists to be used.
  - d. Quality Audit Procedure:

- 1) Perform scheduled internal audits to verify that quality assurance procedures are being enforced and are functioning as intended to ensure total compliance with the Specifications, Contract Drawings, and all reference standards.
  - 2) Conduct Audit Entrance Meetings with the audited organization's responsible management personnel.
  - 3) Use procedures, standards, and audit checklists to assure substantive audit results.
  - 4) Identify records examined, activities witnessed, and personnel interviewed during the audit.
  - 5) Thoroughly investigate problems and clarify misunderstandings during the course of the audit.
  - 6) Document quality problems uncovered in Audit Finding Reports.
  - 7) Conduct Audit Exit Meetings with responsible personnel; and discuss audit results, problems noted, required corrective action, and schedules for completion of corrective actions.
- e. Quality Audit Personnel:
- 1) Use qualified personnel having no direct responsibilities in the area audited.
  - 2) Document the basis of audit personnel qualification.
- f. Quality Audit Reports:
- 1) Document audit results within a Quality Audit Report.
    - a) Report areas/topics audited.
    - b) Identify the audited organization and report any problems found.
    - c) Address the root causes that led to any nonconforming conditions, and recommend actions to prevent recurrence of the nonconformance.
  - 2) Distribute Quality Audit Reports and Audit Finding Reports to personnel having responsibility for the areas audited within 10 working days following the completion of the audit.
  - 3) Submit all Quality Audit Reports to the Engineer for approval no later than 30 days after each audit.
  - 4) Maintain records of quality audits as quality records, and make them available to the Engineer upon request.
- g. Quality Audit Follow-Up:
- 1) Assure that responses to Audit Finding Reports are complete and accurate.
  - 2) Track and verify corrective action, and close problem reports resulting from audits in a timely fashion.

- 3) Re-audit deficiency areas on an accelerated basis to verify effectiveness of corrective action and actions to preclude recurrence of problems.
- h. Owner Audits:
  - 1) Quality audits of Contractor, Subcontractor, and Supplier activities may be performed by the Owner's representatives to verify compliance with the Specifications and referenced standards.
  - 2) Upon notice by the Engineer, provide timely access to facilities, locations, records, and personnel by the Owner's auditors to facilitate performing Owner audits.
  - 3) Assure cooperation with the Owner's auditors by all Contract personnel.
  - 4) Provide timely and thorough responses to Owner-identified quality problems.
15. Training:
  - a. Establish and maintain documented procedures for identifying training needs and to provide for the training of all personnel performing activities affecting quality.
    - 1) Training must include, but not be limited to, procedures to identify potential quality problems in either the Work or materials; and must include appropriate direction for identifying, reporting, and resolving quality problems.
    - 2) Train the Contractor's quality assurance and quality control personnel so they are qualified for their assigned quality tasks based on having the appropriate education, training, or experience required.
    - 3) Train the workers, Subcontractors, Suppliers, and others who perform tasks affecting quality to comply with the various quality-related procedures defined in the CQAP as they relate to the individual's responsibilities.
    - 4) Develop and maintain a training matrix that lists the following:
      - a) Project personnel by title.
        - (1) Include consultant, Contractor, and Subcontractor personnel.
      - b) Applicable procedures, standards, specifications, or other training materials.
      - c) Type of training (classroom or required reading).
- D. Contractor's Failure to Perform:
  1. In the event the Contractor fails to adequately perform any or all of the provisions of this Section, the Owner, at its sole discretion, reserves the right to have the Engineer perform any or all of the provisions in this

Section and back charge the Contractor for the actual cost to the Owner of such services.

- a. This remedy for the Contractor's failure to perform is in addition to any other right or remedy available to the Owner under this Contract.
2. Refer to Division 100, General Provisions, for additional information regarding the Owner's remedies.

#### 1.4 QUALITY ASSURANCE

##### A. Qualifications:

1. Testing and Inspection Agency Qualifications:
  - a. Each Testing and Inspection Agency must be independent, certified, [must be accredited by one of the accreditation agencies listed in FTA IT-90-5001-02.1 to perform the specific tests or types of tests or calibrations required by the Specifications, ]and comply with the quality standards for testing laboratories of the nationally recognized associations and agencies that promulgate the test standards specified and with the basic requirements of ASTM E 329 and other standards specified in individual Specification Sections.
  - b. Each Testing and Inspection Agency must be capable of performing the reviews, inspections, and testing required of them by this Contract; including but not limited to the following:
    - 1) Inspecting, sampling, and testing proposed materials and production as required by the Engineer for compliance with the Contract Documents.
    - 2) Capable of securing production samples of materials at plants or stockpiles during the course of the work, and testing the samples for compliance with the Contract Documents.
  - c. The Testing and Inspection Agency must be approved by the Engineer, and must also be accepted by the local jurisdictions responsible for building inspection.
  - d. Submit the qualifications and certifications of the proposed Testing and Inspection Agencies to the Engineer for approval.
2. Contractor's Superintendent's Qualifications:
  - a. Employ a superintendent having a minimum of 5 years of construction-related experience with a minimum of 2 years in supervision or management of construction work, and empowered to represent and to act for the Contractor.
  - b. Submit the proposed Contractor's superintendent's resume showing his or her qualifications and experience to the Engineer for approval by the Owner.
3. Contractor's Safety Representative's Qualifications:

- a. Employ a Safety Representative having specialized training, certification, and substantial experience in construction safety supervision, including a working knowledge of applicable U.S. Department of Labor (OSHA) regulations, the ability to develop and conduct safety training courses, and familiarity with the industrial hygiene equipment and testing required for the protection of employees.
  - b. The Contractor's Safety Representative must be acceptable to the Engineer, and his performance will be reviewed on a continuing basis; the Engineer reserves the right to revoke the approval of the Safety Representative and require a replacement.
  - c. Submit the proposed Contractor's Safety Representative's resume showing his name, qualifications, and experience to the Engineer for approval.
4. Contractor's Quality Assurance Manager's Qualifications:
- a. Employ a Contractor's Quality Assurance Manager having a minimum of 5 years of construction-related Quality Assurance experience with a minimum of 2 years in supervision or management of Quality Assurance work.
  - b. The Contractor Quality Assurance Manager must be acceptable to the Engineer.
  - c. Submit the proposed Contractor's Quality Assurance Manager's resume showing his name, qualifications, and experience to the Engineer for approval.
- B. Regulatory Requirements:
1. Codes and Reference Standards:
    - a. Fully comply with the applicable requirements of the codes and reference standards specified or indicated in the Contract Documents.
    - b. The versions and editions of the codes and reference standards that are applicable to this Contract are as stipulated on the Contract Documents
      - 1) The applicable versions or editions of the codes and reference standards may not be the most recently published version if the authority having jurisdiction over the Work has adopted some earlier version or edition by regulation, or if newer versions or editions are published after the Contract is awarded.
  2. Rules, Laws, and Regulations:
    - a. Comply with the applicable federal, state, and local rules, laws, and regulations whether or not such rules, laws, and regulations are specifically identified in the Contract Documents or not.
      - 1) Governmental Safety Regulations:

- a) Comply with all applicable U.S. Department of Labor safety regulations, including those stipulated in 29 CFR 1910 and 29 CFR 1926.
  - b) Utility Regulations:
    - (1) In accordance with the Pipeline Inspection, Protection, Enforcement, and Safety Act of 2006 (Title 49 of the United States Code as amended by H.R. 5782) and, the Contractor is required to dial “811” within the state in which the Site is located to identify and locate underground utilities and interferences; and is responsible for notifying affected underground utility owners prior to all excavations and for coordinating utility interconnections and interfaces with the utilities.
    - (2) The Contractor is required to notify public utilities operating overhead power lines whenever construction operations are within clearance envelopes established by statute.
    - (3) For the cranes and similar equipment proposed for use in support of construction and capable of encroachment, submit sketches that define the operation of the equipment and calculations demonstrating that the crane capacities are adequate for the loads applied to the Engineer.
      - (a) Show planned locations and movements of the equipment, the relationship of the equipment footprint to the movement of the crane boom and loads relative to existing structures and surrounding buildings, support grillages and the protection of existing utilities and facilities, and other pertinent details as required by the Engineer.
3. Fees, Royalties, and Taxes:
- a. Unless specifically indicated otherwise, pay all applicable patent and other fees, royalties, and taxes pertaining to the Work of this Contract.
4. Permits and Licenses:

- a. Unless specifically indicated otherwise, procure and pay for all permits and licenses applicable to the Work of this Contract.
- C. Field Samples and Mock-Ups:
1. When specified, provide Samples and mock-ups that illustrate functional and aesthetic characteristics similar in every way to the actual materials or equipment to be incorporated into the work.
    - a. Provide office Samples of sizes and quantities that clearly illustrate the full color range and functional characteristics of products and materials, including attachment devices.
    - b. Furnish required Samples and mock ups at no additional cost to the Owner.
  2. Erect field Samples and mock-ups at the Work Site as specified in individual Specification Sections, and as may be necessitated by the Contractor submitting value engineering proposals, at locations acceptable to the Engineer.
    - a. Do not incorporate the Sample or mock-up material or equipment into the Work until approval to do so is received from the Engineer.

## 1.5 EXISTING CONDITIONS

- A. Obtain full knowledge through personal and careful examination of the existing conditions at the Site that may affect the Work, accept the existing conditions, and assume the responsibility, including any related costs, for failure of the Contractor to obtain full knowledge of the existing conditions.
1. Information regarding existing conditions at the Site as indicated on the Contract Drawings or in the Specifications is given only for the convenience of the Bidders and Contractors, and to present a general representation of present conditions.
    - a. The Contract Drawings may not reflect actual details or dimensions, and should not be relied on for accurate layout, design, or estimating purposes.
  2. Bidders and Contractors assume responsibility for the costs arising from their failure to note variations between the information presented on the Contract Drawings or in the Specifications and the actual existing conditions.

## PART 2 PRODUCTS

### 2.1 SOURCE QUALITY CONTROL

- A. Perform source quality control functions for this Contract in accordance with the approved Contractor Quality Assurance Plan (CQAP), the requirements of Division 100, General Provisions, and of individual Specification Sections.

**PART 3 EXECUTION**

3.1 FIELD QUALITY CONTROL

- A. Perform field quality control function for this Contract in accordance with the approved Contractor Quality Assurance Plan (CQAP), the requirements of Division 100, General Provisions, and of other individual Specification Sections.

**END OF SECTION**

## SECTION 024116 - STRUCTURE DEMOLITION

### PART 1 - GENERAL

#### 1.1 SUMMARY

A. Section Includes:

1. Demolition and removal of buildings and site improvements.
2. Removing below-grade construction.
3. Disconnecting, capping or sealing, and removing site utilities.

#### 1.2 DEFINITIONS

- A. Remove: Detach items from existing construction and legally dispose of them off-site unless indicated to be removed and salvaged.
- B. Remove and Salvage: Carefully detach from existing construction, in a manner to prevent damage, and deliver to Owner. Include fasteners or brackets needed for reattachment elsewhere.

#### 1.3 MATERIALS OWNERSHIP

- A. Unless otherwise indicated, demolition waste becomes property of Contractor.
- B. Historic items, relics, antiques, and similar objects including, but not limited to, cornerstones and their contents, commemorative plaques and tablets, and other items of interest or value to Owner that may be uncovered during demolition remain the property of Owner.
1. Carefully salvage in a manner to prevent damage and promptly return to Owner.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified refrigerant recovery technician.
- B. Proposed Protection Measures: Submit informational report, including Drawings, that indicates the measures proposed for protecting individuals and property, for environmental protection, for dust control and, for noise control. Indicate proposed locations and construction of barriers.
- C. Schedule of Building Demolition Activities: Indicate the following:
1. Detailed sequence of demolition work, with starting and ending dates for each activity.
  2. Shutoff and capping or re-routing of utility services.

- D. Predemolition Photographs: Show existing conditions of adjoining construction and site improvements, including finish surfaces, that might be misconstrued as damage caused by demolition operations. Submit before the Work begins.
- E. Landfill Records: Indicate receipt and acceptance of hazardous wastes by a landfill facility licensed to accept hazardous wastes.
- F. Statement of Refrigerant Recovery: Signed by refrigerant recovery technician responsible for recovering refrigerant, stating that all refrigerant that was present was recovered and that recovery was performed according to EPA regulations. Include name and address of technician and date refrigerant was recovered.

#### 1.5 QUALITY ASSURANCE

- A. Refrigerant Recovery Technician Qualifications: Certified by EPA-approved certification program.
- B. Regulatory Requirements: Comply with governing EPA/DNREC notification regulations before beginning demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.
- C. Standards: Comply with ANSI/ASSE A10.6 and NFPA 241.
- D. Predemolition Conference: Conduct conference at Project site.
  - 1. Inspect and discuss condition of construction to be demolished.
  - 2. Review and finalize building demolition schedule and verify availability of demolition personnel, equipment, and facilities needed to make progress and avoid delays.
  - 3. Review and finalize protection requirements.
  - 4. Review procedures for noise control and dust control.
  - 5. Review procedures for protection of adjacent buildings.

#### 1.6 PROJECT CONDITIONS

- A. Buildings to be demolished will be vacated and their use discontinued before start of the Work.
- B. Buildings immediately adjacent to demolition area will be occupied. Conduct building demolition so operations of occupied buildings will not be disrupted.
  - 1. Provide not less than 72 hours' notice of activities that will affect operations of adjacent occupied buildings.
  - 2. Maintain access to existing walkways, exits, and other facilities used by occupants of adjacent buildings.

- a. Do not close or obstruct walkways, exits, or other facilities used by occupants of adjacent buildings without written permission from authorities having jurisdiction.
- C. Owner assumes no responsibility for buildings and structures to be demolished.
  - 1. Conditions existing at time of inspection for bidding purpose will be maintained by Owner as far as practical.
  - 2. Existing site lighting and poles are the property of the utility company. Coordinate with the utility company for removal of the fixtures.
- D. Existing structures to remain: Two existing billboards are located on the Owner's property but do not belong to the Owner. Billboards shall remain, including any power service and lighting associated with the billboards. Coordinate any service interruptions or utility relocations with the billboards owner(s).
- E. Hazardous Materials: It is not expected that hazardous materials will be encountered in the Work.
  - 1. Hazardous materials will be removed by Owner before start of the Work.
  - 2. If materials suspected of containing hazardous materials are encountered, do not disturb; immediately notify Architect and Owner. Hazardous materials will be removed by Owner under a separate contract.
- F. On-site storage or sale of removed items or materials is not permitted.

## **PART 2 - PRODUCTS**

(Not Used)

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Verify that utilities have been disconnected and capped before starting demolition operations.
- B. Inventory and record the condition of items to be removed and salvaged. Provide photographs of conditions that might be misconstrued as damage caused by salvage operations.
- C. Verify that hazardous materials have been remediated before proceeding with building demolition operations.

### 3.2 PREPARATION

- A. Refrigerant: Remove refrigerant from mechanical equipment according to 40 CFR 82 and regulations of authorities having jurisdiction before starting demolition.
- B. Existing Utilities: Locate, identify, disconnect, and seal or cap off indicated utilities serving buildings and structures to be demolished.
  - 1. Arrange to shut off indicated utilities with utility companies.
  - 2. Cut off pipe or conduit a minimum of 24 inches below grade. Cap, valve, or plug and seal remaining portion of pipe or conduit after bypassing according to requirements of authorities having jurisdiction.
- C. Existing Utilities: See plumbing and electrical Sections for shutting off, disconnecting, removing, and sealing or capping utilities. Do not start demolition work until utility disconnecting and sealing have been completed and verified in writing.
- D. Temporary Shoring: Provide and maintain interior and exterior shoring, bracing, or structural support to preserve stability and prevent unexpected movement or collapse of construction being demolished.
  - 1. Strengthen or add new supports when required during progress of demolition.

### 3.3 PROTECTION

- A. Existing Utilities: Maintain utility services to remain and protect from damage during demolition operations.
  - 1. Do not interrupt existing utilities serving adjacent occupied or operating facilities unless authorized in writing by Owner and authorities having jurisdiction.
  - 2. Provide temporary services during interruptions to existing utilities, as acceptable to Owner and authorities having jurisdiction.
    - a. Provide at least 72 hours' notice to occupants of affected buildings if shutdown of service is required during changeover.
- B. Temporary Protection: Erect temporary protection, such as walks, fences, railings, canopies, and covered passageways, where required by authorities having jurisdiction and as indicated.
  - 1. Protect adjacent buildings and facilities from damage due to demolition activities.
  - 2. Protect existing site improvements, appurtenances, and landscaping to remain.

3. Erect a plainly visible fence around drip line of individual trees or around perimeter drip line of groups of trees to remain.
  4. Provide temporary barricades and other protection required to prevent injury to people and damage to adjacent buildings and facilities to remain.
  5. Provide protection to ensure safe passage of people around building demolition area and to and from occupied portions of adjacent buildings and structures.
  6. Protect walls, windows, roofs, and other adjacent exterior construction that are to remain and that are exposed to building demolition operations.
  7. Erect and maintain dustproof partitions and temporary enclosures to limit dust, noise, and dirt migration to occupied portions of adjacent buildings.
- C. Remove temporary barriers and protections where hazards no longer exist. Where open excavations or other hazardous conditions remain, leave temporary barriers and protections in place.

### 3.4 DEMOLITION, GENERAL

- A. General: Demolish indicated buildings and site improvements completely. Use methods required to complete the Work within limitations of governing regulations and as follows:
1. Do not use cutting torches until work area is cleared of flammable materials. Maintain portable fire-suppression devices during flame-cutting operations.
  2. Maintain adequate ventilation when using cutting torches.
  3. Locate building demolition equipment and remove debris and materials so as not to impose excessive loads on supporting walls, floors, or framing.
- B. Engineering Surveys: During demolition, perform surveys to detect hazards that may result from building demolition activities.
- C. Site Access and Temporary Controls: Conduct building demolition and debris-removal operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.
1. Do not close or obstruct streets, walks, walkways, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.
  2. Use water mist and other suitable methods to limit spread of dust and dirt. Comply with governing environmental-protection regulations. Do not use water when it may damage adjacent construction or create hazardous or objectionable conditions, such as ice, flooding, and pollution.
- D. Explosives: Use of explosives is not permitted.

### 3.5 DEMOLITION BY MECHANICAL MEANS

- A. Proceed with demolition of structural framing members systematically, from higher to lower level. Complete building demolition operations above each floor or tier before disturbing supporting members on the next lower level.
- B. Remove debris from elevated portions of the building by chute, hoist, or other device that will convey debris to grade level in a controlled descent.
  - 1. Remove structural framing members and lower to ground by method suitable to minimize ground impact and dust generation.
- C. Below-Grade Construction: Demolish foundation walls and other below-grade construction.
  - 1. Remove below-grade construction, including basements, foundation walls, and footings, completely.
- D. Existing Utilities: Demolish and remove existing utilities and below-grade utility structures.
  - 1. Piping: Disconnect piping at unions, flanges, valves, or fittings.
  - 2. Wiring Ducts: Disassemble into unit lengths and remove plug-in and disconnecting devices.

### 3.6 REPAIRS

- A. Promptly repair damage to adjacent buildings caused by demolition operations.

### 3.7 DISPOSAL OF DEMOLISHED MATERIALS

- A. Remove demolition waste materials from Project site and legally dispose of them in an EPA/DNREC-approved landfill acceptable to authorities having jurisdiction.
  - 1. Do not allow demolished materials to accumulate on-site.
  - 2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.
- B. Do not burn demolished materials.

### 3.8 CLEANING

- A. Clean adjacent structures and improvements of dust, dirt, and debris caused by building demolition operations. Return adjacent areas to condition existing before building demolition operations began.
  - 1. Clean roadways of debris caused by debris transport.

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**END OF SECTION**

## **SECTION 031500 - FORMWORK**

### **PART 1 - GENERAL**

#### **1.1 DESCRIPTION**

This section specifies labor, materials, equipment and services necessary for and reasonably incidental to the design, construction and removal of formwork for cast-in-place concrete.

#### **1.2 QUALITY ASSURANCE**

Formwork shall conform to the requirements and provisions of the following publications. In the ACI publications referred to herein, the advisory provisions shall be considered mandatory, as though the word "shall" has been substituted for "should" wherever it appears.

- A. American Concrete Institute (ACI) 301 (2011) "Standard Specifications for Structural Concrete".
- B. American Concrete Institute (ACI) 318 (2011) "Building Code Requirements for Structural Concrete".
- C. American Concrete Institute (ACI) 347 R (2004) "Guide to Formwork for Concrete."

#### **1.3 RESPONSIBILITY FOR FORMWORK**

Form design, engineering, erection, construction, bracing, shoring, stripping, removal, reshoring, etc. are the Contractor's complete responsibility.

#### **1.4 SUBMITTALS**

- A. Samples or Manufacturers Literature: Furnish for the following materials, for approval prior to construction:
  - 1. Form ties
  - 2. Form oils, release agents, parting compounds
  - 3. Plywood and fiberglass forms for exposed concrete
- B. Shop Drawings of typical areas of forms for concrete work shall be submitted prior to fabrication and assembly. Show and coordinate layout and arrangement of construction joints, form panel joints and spacing of wall form ties for the full height of each wall.

## **PART 2 - PRODUCTS**

### **2.1 FORMS FOR UNEXPOSED CONCRETE**

- A. Unexposed concrete surfaces shall be defined as the exterior surfaces of the concrete that will be below the finished grade around the structure and shall be permanently in contact with soil or the surfaces to be covered by face brick.
- B. Plywood - American Plywood Association: EXT-APA (High-density overlay B-B Plyform, Class II). OR
- C. Substantial Steel sheet metal for subgrade and other unexposed work. Clean the forms and remove nails when reusing.

### **2.2 FORMS FOR EXPOSED CONCRETE**

- A. All concrete surfaces other than those defined as "unexposed concrete surfaces" in paragraph 2.01 shall be considered exposed concrete surfaces.
- B. Plywood - American Plywood Association - EXT-APA, age sealed, sanded, grade trade-marked (High Density Overlay B-B Plyform Class I). OR
- C. Steel sheet metal. Steel form surfaces shall not contain irregularities, dents or sags. Overlay shall not stain the surface of the concrete. Apply form sealer to all form surfaces in contact with finish faces of exposed concrete. Form sealer shall be compatible with paint and other finishes that will be applied to the concrete.

### **2.3 BRACING, WALERS, STUDS, SHORES, RESHORES**

- A. Metal, or suitable graded lumber, of substantial size and configuration for loads to be supported.

### **2.4 FORM TIES**

- A. Plastic cone type, with threaded steel rod or wire, with waterstop, as approved. Submit sample prior to commencing formwork. Rod type or wire type shall have no metal closer than 1-1/2" to finish surface.

### **2.5 FORM OILS, RELEASE AGENTS, PARTING COMPOUNDS**

- A. Approved release, parting or "oil" materials must be compatible with the specified forms, with fair-faced exposure and with future finishes. Coat all forms properly before placing reinforcement and embedded items.

## **PART 3 - EXECUTION**

### **3.1 FORMWORK FUNCTIONAL DESIGN**

- A. Formwork shall be capable of containing concrete in its plastic state without loss of water or cement paste, and be removable without damage to concrete surfaces and edges. Arrange formwork for convenient inspection, cleaning, depositing and placement of concrete and draining of water. Design all components (form panels, connections, shoring, bracing, supports, reshores) to resist all live and dead loads, (wind, reshores, construction loads, traffic vibration) that will occur while in use. Design shall include the slow gain of concrete strength with age of previously cast members. Formwork shall be designed such that there is no deflection or weakness affecting established alignment of concrete surfaces. Provide all necessary shores, stringers, soffit forms and the like. Standard of formwork construction shall be ACI-347 R.

### **3.2 FORMWORK CONFORMATION**

- A. Construct formwork with minimum practicable tolerances to produce concrete work true to lines, dimensions, shapes, locations, grades and elevations established on Contract Drawings. Provide all recesses, pockets, utility outlets, joints, keys and projections, notches, and openings.

### **3.3 WORKMANSHIP AND INSTALLATION**

- A. All workmanship shall be in best formwork and carpentry practice. Formwork shall be installed with all proper bracing, connections, rough hardware and proper fastenings for the anchoring materials, for a rigid, secure and complete job.
- B. Special Care Required: At ALL exposed concrete.
- C. Framing and Blocking Lumber: Properly framed, closely fit, accurately set to required lines and levels, plumb, straight and true, and rigidly secure in place, with proper fastenings to adjacent materials.
- D. Construction Tolerances: Construction tolerances shall be in accordance with ACI 301.
- E. Joints, Openings, Recesses: Construct all indicated and required conditions, keys, jointing details and openings in strict accordance with indicated details; consult Drawings of all trades. Joints not indicated on Drawings, but desired by Contractor for construction jointing in Project sequences, shall be so located and built as not to impair strength of structure. Contractor shall seek written approval in advance from the Engineer for additional or relocated joints.
- F. Protection for Re-Use: Provide protection and care in handling and stripping and re-use location-to-location to assure continuing acceptability of condition of forms. Form units which are distorted, have an excessive number of patches, have

delaminated areas of the plywood surface, etc. shall not be reused. Acceptability of re-used forms shall be as determined by The Engineer.

- G. Avoidance of 'Pillow-Effect' or Form-Bulge: Provide adequate forming, bracing and tying as required. In addition, vertical rate-of-placement shall be controlled by the Contractor to avoid excessive liquid heads on formed faces prior to setting of concrete.
- H. Inserts, Attachments, Accessories to be Embedded in Concrete: Proper location, setting, spacing, anchorage and coordination with reinforcing and all related trades, are Contractor's responsibility.

### 3.4 REMOVAL OF FORMS

- A. Unless otherwise authorized, forms shall not be removed before the expiration of the minimum number of days implicit in the following table:

Walls	1 day
Footings	1 day
Elevated Slabs under 10 ft. clear span between Structural supports	3 days

The times shown represent cumulative number of days, not necessarily consecutive, during which the temperature of the air surrounding the concrete is above 50°F.

- B. Form removal shall be carried out in such a manner as to assure the complete safety and integrity of the formed surface of the structure. In no case shall any form or shoring be removed or disturbed until the concrete has thoroughly hardened and acquired sufficient strength to safely support its own weight and the live load upon it.
- C. Sufficient shoring and reshoring shall be kept in place to properly support the concrete structure after the forms have been removed and until such time as it is no longer necessary. All forms shall be so designed as to permit this to be done. Reshoring of concrete beams and slabs shall take into account necessary spacing, dead and live loads, and the age and rate of gain of strength of concrete. Reshores shall remain in position at least 28 days. Reshoring shall be planned in advance and shall be subject to review by The Engineer.

### 3.5 REJECTED MATERIAL

- A. Materials, deliveries, completed work or job conditions condemned or rejected by The Engineer as failing to meet Contract Specification quality shall be removed and replaced without delay, at Contractor's expense, as directed by The Engineer. The Engineer's decisions shall be final and will be based solely on these Contract Specifications and engineering standards.

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**END OF SECTION**

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## **SECTION 032000 - REINFORCING STEEL**

### **PART 1 - GENERAL**

#### 1.1 DESCRIPTION

This section specifies labor, materials, equipment and services necessary for and reasonably incidental to the furnishing and installation, complete of all reinforcement for concrete structures.

#### 1.2 QUALITY ASSURANCE

Details and placement of concrete reinforcement and accessories shall conform to the following publications. In the ACI publications referred to herein, the advisory provisions shall be considered mandatory, as though the word "shall" has been substituted for "should" wherever it appears.

- A. American Concrete Institute (ACI)
  - 1. ACI 301 (2010)- "Standard Specifications for Structural Concrete."
  - 2. ACI SP-66 (2004)- "ACI Detailing Manual."
- B. ASTM
  - 1. ASTM A185(2007) – "Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement."
  - 2. ASTM A615(2012)- "Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement."
- C. Concrete Reinforcing Steel Institute (CRSI)
  - 1. Manual of Standard Practice
  - 2. Placing Reinforcing Bars

#### 1.3 QUALITY CONTROL

- A. Furnish certified copy of mill tests on each heat, showing chemical and physical analysis.

#### 1.4 SUBMITTALS

- A. Submit shop drawings for approval, prior to fabrication, showing all fabrication dimensions, placement plans and bar lists with bar bending diagrams for all reinforcement. Shop drawings shall not be reprints of the Contract Drawings. Shop drawings shall conform to the standards listed above.

### **PART 2 - PRODUCTS**

#### 2.1 MATERIALS

- A. Deformed Reinforcing Steel: ASTM A615, Grade 60.

- B. Accessories shall conform to the ACI Detailing Manual SP-66.
- C. Welded wire fabric: ASTM A185.
- D. Dowel Bar Splicer: Dowel bar splicer shall be capable of developing at least 125 percent of the specified yield strength of the bar and shall be as manufactured by Richmond Screw Anchor Co., Inc. or approved equal.

## 2.2 FABRICATION

- A. Fabricate each unit of reinforcement in accordance with the approved shop drawings.
- B. Reinforcement shall be bent as required in ACI 318. The use of heat to bend or straighten reinforcing steel will not be permitted.

## 2.3 HANDLING AND STORAGE

- A. Reinforcement shall be shipped to the work site with bars of the same size and shape fastened in bundles, with metal identification tags giving size and mark securely wired on. The identification tag shall be labeled with the same designation as shown on the approved submittals.
- B. Reinforcement shall be stored off the ground, protected from moisture, and kept free of dirt, oil, or injurious contaminants.

## **PART 3 - EXECUTION**

### 3.1 PLACING AND FASTENING

- A. The lap length shall be as shown on the drawings. All hooks shall be detailed as ACI standard hooks unless otherwise indicated.
- B. Secure the reinforcement in such a manner that its displacement does not exceed the limits noted in ACI-301. The ends of all tie wires shall be bent away from forms.
- C. Reinforcement supported from an earth surface shall utilize precast concrete blocks in accordance with ACI-301. Masonry supports are not acceptable.
- D. Prior to placement of concrete, reinforcement shall be free of mud, oil, ice or other material that may adversely affect or reduce the bond. Rust, seams, surface irregularities or mill scale shall not be cause for rejection provided the weight, dimensions, cross sectional area, and tensile properties of a cleaned test specimen are not less than the requirements of the applicable ASTM specifications.

3.2 CLEAR COVER

- A. All reinforcement shall have a clear cover from the outside of the bar to the concrete surface as noted on the Contract Drawings.

3.3 SPLICING

- A. Splices shall be used only where indicated on the Contract Drawings. When splicing bars of different diameters, the minimum lap length is governed by the smaller diameter bar.
- B. Overlap welded wire fabric a minimum of 1'-0".

**END OF SECTION**

## SECTION 033000 - CAST-IN-PLACE CONCRETE

### PART 1 - GENERAL

#### 1.1 DESCRIPTION

- A. This section specifies labor, materials, equipment and services necessary for and reasonably incidental to furnishing and installation, complete, of all cast-in-place concrete.
- B. Related work not included in this section specified elsewhere:
  - 1. Formwork: Section 03150
  - 2. Reinforcing Steel: Section 03200

#### 1.2 QUALITY ASSURANCE

Concrete work shall conform to the requirements and provisions of the following publications. In the ACI publications referred to herein, the advisory provisions shall be considered mandatory, as though the word "shall" has been substituted for "should" wherever it appears.

- A. American Concrete Institute (ACI)
  - 1. ACI 301 (2010) - "Specification for Structural Concrete".
  - 2. ACI 302.1R (2004) - "Guide for Concrete Floor and Slab Construction".
  - 3. ACI 304R(2000) - "Guide for Measuring, Mixing, Transporting and Placing Concrete".
  - 4. ACI 305R (2010) - "Hot Weather Concreting".
  - 5. ACI 306R(2010) - "Cold Weather Concreting".
  - 6. ACI 309R (2005) - "Guide for Consolidation of Concrete".
  - 7. ACI 318 (2011) - "Building Code Requirements for Structural Concrete and Commentary".
  - 8. ACI 350R (2006) - "Environmental Engineering Concrete Structures".
- B. ASTM
  - 1. ASTM C31 (2012) - "Test Methods of Making and Curing Concrete Test Specimens in the Field".
  - 2. ASTM C33 - (2013) "Specification for Concrete Aggregate".
  - 3. ASTM C94 - (2013) "Specification for Ready-Mixed Concrete".
  - 4. ASTM C143 - (2012) "Test Method for Slump of Portland Cement Concrete".
  - 5. ASTM C150 - (2012) "Specification for Portland Cement".
  - 6. ASTM C171 - (2007) "Specification for Sheet Materials for Curing".
  - 7. ASTM C172 - (2007) "Method for Sampling Freshly Mixed Concrete".
  - 8. ASTM C231 - (2010) "Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method".
  - 9. ASTM C260 - (2010) "Specification for Air-Entrained Admixtures for Concrete".

10. ASTM C308 - (2012) "Test Methods for Working and Setting Times of Chemical Resistant Resin Mortars".
11. ASTM C309 - (2011) "Specification for Liquid Membrane-Forming Compounds for Curing Concrete".
12. ASTM C494 - (2011) "Specification for Chemical Admixtures for Concrete".
13. ASTM C989 - (2012) "Specification for Ground Granulated Blast Furnace Slag for Use in Concrete or Mortars".
14. ASTM D1752 - (2008) "Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction".
15. ASTM E96 - (2012) "Standard Test Methods for Water Vapor Transmission of Materials".
16. ASTM E1643 - (2011) "Standard Practice for Installation of Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs".
17. ASTM E1745 - (2011) "Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs".

### 1.3 FIELD QUALITY CONTROL AND CONCRETE TESTING

- A. Independent Testing Laboratory: The Contractor shall employ at his own expense an independent testing laboratory, approved by the Engineer, to perform the inspection and testing services specified in ACI 301, Section 1, Paragraph 1.6, "Quality Assurance". This independent testing laboratory shall be considered as the 'Owner's testing agency' as described in ACI 301 and shall be responsible for all the testing that is to be performed by the 'owner's testing agency'.
- B. Test Specimens: In addition to the above, the Contractor shall supply all concrete, compression test molds, tamping rods, trowel, metal or glass covers, slump cone, storage box and sand necessary for making test specimens as outlined herein. The Contractor shall make, cure, and remove from molds and transport to the testing laboratory, three specimens for each sample in accordance with ASTM C172 and C31.
- C. Extent of Tests: Prepare one sample for strength testing for each 100 cu. Yds. or fraction thereof, for each mixture design of concrete placed in any one day.
- D. Test Reports: Contractor shall fill in data on concrete test sample form and forward the same with test specimens to the testing laboratory. When tests have been conducted, the contractor shall furnish the results of the tests with all pertinent data to the Engineer.
- E. Deficiencies and Remedial Action: In the event that concrete strength test results do not meet the acceptance criteria specified in ACI 301, additional tests of concrete in place as specified in ACI 301 shall be performed at the sole expense of the Contractor. In the event that tests of concrete in place do not meet the acceptance criteria specified in ACI 301, those portions of the structure affected,

as determined by the Engineer, shall be removed and replaced in a manner acceptable to the Engineer and at no additional expense to the Owner.

- F. Slump Tests: The Contractor shall also check the consistency of concrete by means of slump tests conducted in accordance with ASTM C143. The slump tests shall be made at the same time that the compression test specimens are made or as directed by the Engineer.
- G. Air Content Test: The Contractor shall also test the air content in accordance with ASTM C231. The air content test shall be performed on the same test specimens designated for compression testing or as directed by the Engineer.
- H. Supervision of Tests: The making of all concrete specimens, slump, and air content tests shall be witnessed by the Engineer.

#### 1.4 SUBMITTALS

- A. Design Mix: At least 31 days prior to start of placing concrete, submit design mix for concrete, indicating that the concrete ingredients and proportions will result in a concrete mix meeting requirements specified.
- B. Hot and Cold Weather Concreting: Submit proposed methods for compliance with cold and hot weather mixing and delivery recommendation of ACI 305R and ACI 306R.
- C. Certificates:
  - 1. Submit with each mix design, laboratory test reports and manufacturer's certificates attesting to conformance of ingredients with specifications. Include 28 day compressive strength test results certifying compliance with the requirements herein.
  - 2. In case the source, brand or characteristic properties of the ingredients need to be varied during the term of the Contract, submit revised design mix and manufacturer's certificates.
  - 3. Submit certificate stating that each admixture used is identical in composition to the sample used for acceptance testing and is compatible with all other materials in the design mix.
  - 4. Submit certificate stating that the concrete vibrator operators have the required experience in operating the equipment.
- D. Batch Tickets: Submit a delivery ticket from the concrete supplier with each batch delivered to the site setting forth the following information:
  - 1. Name of supplier;
  - 2. Name of batching plant and location;
  - 3. Serial number of ticket;
  - 4. Date;
  - 5. Truck number and batch number;
  - 6. Specific job designation;
  - 7. Volume of concrete (cubic yards);

- 8. Specific class of concrete;
- 9. Time loaded and amount of water added;
- 10. Type and brand of cement;
- 11. Weight of cement;
- 12. Maximum size of aggregates;
- 13. Weights of coarse and fine aggregates, respectively;
- 14. Type and amount of admixtures; and
- 15. Mix design designation.

- E. Manufacturer's Data: Submit manufacturer's data with installation instructions for all materials, including but not limited to, admixtures, curing compound and materials, coatings, waterstops, vapor barrier and joint materials.
- F. All submittals shall state the location(s) and application(s) for each material.

1.5 GENERAL REQUIREMENTS

- A. Concrete work shall conform to the applicable requirements of ACI 301, except as modified herein.

**PART 2 - PRODUCTS**

2.1 CONCRETE

- A. Normal Weight Concretes:

Location	28 Day Compressive Strength (psi)	Aggregate Size Number	Minimum Cement Content (lbs/cy)
All Concrete	4,500	57	611

All concrete fill shall have a minimum compressive strength of 4500 psi at 28 days and shall be placed only where noted on the contract drawings.

- B. Provide air-entrained concrete with air content of 6 percent plus or minus 1 percent for concrete exposed to weather. Do not allow air content of interior floors to exceed 3 percent.
- C. Maximum water cement ratio of 0.45.
- D. Maintain the slump range for concrete at the point of delivery within the following limits:
  - 1. Concrete flatwork and incidental construction 2-3 inches
  - 2. All Other 2-4 inches

## 2.2 MATERIALS

- A. Cementitious Compounds
  - 1. Cement: ASTM C150, Type I/II or Type II. For exposed concrete use one manufacturer of cement.
  - 2. Ground Granulated Blast-Furnace Slag: ASTM C989.
    - a. When Ground Granulated Blast-Furnace Slag is used, its proportion by weight shall be no more than 40 percent of total cementitious material.
- B. Aggregates: Concrete aggregates: ASTM C33. Aggregate may be crushed stone, natural or manufactured sand. Uniformity of grading and moisture content shall be obtained by methods recommended in ACI 304.
- C. Admixtures and Additives:
  - 1. Air Entraining Admixtures: ASTM C260.
  - 2. Water Reducing and Retarding Admixtures: ASTM C494, Type D.
  - 3. Water Reducing Admixture: ASTM C494, Type A.
  - 4. Concrete for structural elements coming in direct contact with process liquid and outside earth shall contain crystalline waterproofing additive. Quantity of the admixture shall be 2% to 3% as recommended by the manufacturer. Acceptable products shall be AQUAFIN-IC ADMIX as manufactured by Aquafin, Inc., XYPEX ADMIX C-500 as manufactured by Xypex Chemical Corporation, Penetron Admix as manufactured by ICS Penetron International LTD. or equivalent product as approved by Owner's Representative.
  - 5. The use of anti-freeze compounds, salts, chemicals or other foreign materials, for the purpose of lowering the freezing point of the concrete is prohibited. No calcium chloride or ingredients containing chloride shall be mixed in any concrete.
  - 6. Admixtures used in concrete to receive surface hardener shall be compatible and approved for use by the surface hardener manufacturer.
- D. Water used in mixing concrete shall be clean and free from injurious amount of oil, acids, alkalis, organic materials or other deleterious substances.
- E. Curing or Curing and Hardening Compounds: ASTM C309, Type I-D.
- F. Sheet Materials for Curing Concrete: ASTM C171.

## PART 3 - EXECUTION

### 3.1 PREPARATION OF EQUIPMENT AND PLACE OF DEPOSIT

- A. Before placing concrete, all equipment for mixing and transporting the concrete shall be cleaned; all debris and ice shall be removed from places to be occupied by the concrete; forms shall be thoroughly oiled and the reinforcement shall be thoroughly cleaned of ice or other non-specified coatings.

- B. Excess water shall be removed from place of deposit before concrete is placed, unless otherwise permitted by the Engineer.
- C. Before placing any concrete, the Contractor shall install all reinforcement, sleeves, anchors, fittings, pipes, conduits, etc., called for or required by the provisions of other sections of these specifications or noted on the drawings. Vapor barrier shall be installed in accordance with manufacturer's instructions and ASTM E 1643. All penetrations including pipes shall be sealed using pipe boots made from the vapor barrier material and sealing tape. Any damaged areas of vapor barrier shall be repaired by using patches of vapor barrier material, overlapping the damaged area a minimum of 6 inches and taping all sides. No concrete shall be placed until this work has been approved by the Engineer.
- D. The Contractor shall ascertain that all material to be installed in the concrete by other trades has been placed prior to pouring any concrete.

### 3.2 READY-MIXED CONCRETE

- A. Ready-mixed concrete shall be in conformance with ASTM C94.
- B. The volume of any batch mixed shall not exceed the manufacturer's rated capacity of the mixer used.
- C. Mixing time shall be as specified in ASTM C94, but during hot weather or other conditions contributing to quick stiffening of concrete, the Engineer may require the Contractor to limit the discharge time to LESS than one hour or 300 revolutions of the mixer, whichever comes first.
- D. No materials for a batch of concrete shall be placed in the drum of a mixer until all the previous batch has been discharged. Mixers shall be kept free and clean of accumulations of hardened concrete and any incrustations of inert materials.
- E. The effective moisture contained in the aggregate shall be included in the total amount of mixing water used. In the absence of a field determination of the moisture content of the aggregates, the following shall be assumed: fine aggregate, 1/2 gallon per cubic foot and coarse aggregate 1/4 gallon per cubic foot. The quantity of mixing water to be used shall include the moisture in the aggregates above the state of saturated and surface dry.
- F. Water shall not be added to the mix after departure from the batching plant without the Engineer's permission. In no case shall the maximum water cement ratio be exceeded.
- G. If it becomes necessary to mix a small portion of concrete by hand, permission shall be obtained from the Engineer. In that case, if allowed, the total quantity of such batches shall not exceed 1/2 cubic yard. The materials shall be accurately measured and shall be mixed dry in a watertight, metal mortar box in order to prevent loss of cement. Mixing on the bare ground or on floors of buildings will

not be permitted under any circumstances. The mass shall be thoroughly turned over at least 6 times, water being added after the third time.

### 3.3 CONVEYING

- A. Handle concrete from the mixer to the place of final deposit as rapidly as practicable by methods that will prevent segregation, undue drying or temperature rise, or loss of ingredients, and in a manner that will maintain the required quality of concrete
- B. Use conveying equipment of size and design to maintain a continuous flow of concrete at the delivery end, and as approved by the Engineer. Do not use conveying equipment with aluminum parts, such as chutes, hoppers, or scrapers, that could come in contact with and contaminate the concrete during conveying.
- C. Use belt conveyors which are horizontal or at a slope which will cause neither segregation nor loss. Use an approved arrangement at the discharge end to prevent separation. Discharge long runs without separation into hopper. Do not allow concrete to adhere to the return belt.
- D. Use chutes which are metal or metal lined, and have a slope not exceeding one vertical to two horizontal and not less than one vertical to three horizontal. Chutes more than 20 feet long, and chutes not satisfying slope requirements, may be used if the chutes discharge into an approved hopper before distribution.
- E. Use pumping and pneumatic conveying equipment of a suitable kind with adequate pumping capacity. Clean equipment at the end of each operation. Control pneumatic placement so that separation is not apparent in the discharged concrete.

### 3.4 PLACEMENT

- A. General:
  - 1. Placing on Ground or Subcourse: Subgrade or base course shall be free from injurious material, well drained, and moist at time of concreting. Prior to placing concrete, thoroughly clean and dampen as necessary leaving no free water standing on base course or subgrade and no soft or muddy spots in subgrade.
  - 2. Deposit concrete into the forms as nearly as practical to its final position, and in a manner not to cause or permit segregation. Do not use vibrators for extensive shifting of the mass of fresh concrete. The free drop of any concrete shall not exceed three feet without the use of adjustable length pipes. Place concrete for columns by means of pipes adjustable in length and not less than six inches in diameter.
  - 3. Layers of concrete shall not be tapered off in wedge shaped slopes but shall be built with squared ends and level tops. Deposit concrete continuously or in layers of such thickness that no concrete will be deposited on concrete which has hardened sufficiently to cause the

formation of seams or planes of weakness within the section. If a section cannot be placed continuously, locate construction joints at points as indicated or as approved. Place concrete at such a rate that all concrete being integrated with fresh concrete is plastic.

4. Align slab top surfaces to screed contours by strikeoff, or if the nature of the finished surface so requires, by approved vibrating screeds or roller pipe screeds.
5. Do not place concrete in supported elements until concrete previously placed in supporting columns and walls is no longer plastic, or where so indicated, until initial shrinkage has occurred in such supporting concrete members (2 hours minimum).

B. Consolidation: Consolidate concrete in accordance with ACI 309R. Consolidate concrete by means of approved internal vibrators. The vibrator operators shall be experienced in operating the equipment for a minimum of three years.

1. Employ a sufficient number of vibrators to consolidate the incoming concrete to a proper degree within 15 minutes after depositing in forms. In all cases, maintain at least one spare vibrator available at the site of any structure during concrete placement. Do not vibrate the forms or the reinforcing steel.
2. The location, manner and duration of the application of vibrators shall be such as to secure maximum consolidation of the concrete without causing segregation of mortar and coarse aggregate and without causing water or cement paste to flush to the surface. The thickness of the layers shall be not greater than can be satisfactorily consolidated by vibrators. Vibrators shall vertically penetrate a few inches into the previous lift at regular intervals.
3. The use of approved external vibrators for consolidating concrete will be permitted when concrete is inaccessible for adequate consolidation, providing the forms are constructed sufficiently rigid to resist displacements and damage from external vibration.

### 3.5 FINISHING CONCRETE

A. Immediately following removal of forms, cavities produced by form ties and other surface defects shall be repaired in accordance with Section 5 of ACI 301 and as specified hereinafter.

B. Finish of formed surfaces shall be in accordance with Section 5, Paragraph 5.3.3 of ACI 301 as follows as follows:

1. All concrete surfaces below grade and unexposed to view shall be given a rough form finish.
2. All exposed concrete surfaces shall be given a smooth rubbed finish. Abrupt irregularities like fins or offsets shall not be acceptable.

C. Finish of flatwork shall be in accordance with Section 5, Paragraph 5.3.4 of ACI 301 and as follows:

- D. Flatwork shall be given a floated finish, except that flatwork which will be the final walking surface and is exposed to weather shall be given a broom or belt finish

### 3.6 CURING AND PROTECTION

- A. General Requirements:
  - 1. Protect freshly placed concrete from excessively hot or cold temperatures. Maintain without drying for the period of time necessary for the hydration of the cement and the proper hardening of the concrete.
  - 2. Keep concrete continuously under cure until the accumulated time during which the temperature of the air in direct contact with the concrete has been warmer than 50o for at least seven (7) days.
- B. Normal Curing: Use any one of the methods described below.
  - 1. Ponding: Keep the surface submerged at all times for the required curing period. Water temperature shall not be less than 20o below concrete temperature.
  - 2. Continuous Application of Water: Accomplished by sprinkling with a nozzle which so atomizes the flow that a mist and not a spray is formed, until the concrete is set.
  - 3. Covering: Cover the entire area to be cured with double thickness burlap sheet, laid directly on the concrete, and keep continuously wet.
  - 4. Covering with Waterproof Sheeting: Keep the entire area to be cured continuously wet by sprinkling, as specified in paragraph 2 above, for at least 18 hours and then immediately cover with waterproof curing sheet, free of holes or tears.
- C. Curing Compound Method:
  - 1. Curing and hardening compound shall be applied to exposed slabs which do not receive any other surface treatment. Curing compounds shall be applied on all other surfaces.
  - 2. Do not apply the curing compound to the surface of construction joints, to reinforcing steel, or to surfaces which receive cementitious toppings. Do not apply the curing compound to surfaces which receive specialty coatings, including but not limited to; surface hardeners, nonslip finishes and waterproofing compounds; unless written approval of such usage is first obtained from the specialty coating manufacturer.
  - 3. Keep surfaces to be cured moist or wet until the curing compound is applied. Do not apply the curing compound until all patching and surface finishing has been completed.
  - 4. Apply curing compound uniformly over the surface at the rate and thickness recommended by the manufacturer, or if not stipulated, at 200 SF per gallon. Curing compound which becomes chilled to such an extent that it is too viscous for satisfactory application shall be warmed in accordance with the manufacturer's recommendations.

5. Should the film of compound be damaged from any cause before the expiration of the curing period, immediately repair the damaged portions with additional compound.

D. Inclement Weather Protection:

1. When the mean daily temperature of the atmosphere is less than 40o F, maintain the temperature of the concrete between 50 and 70o F when placed and for the required curing period.
2. When necessary, make arrangements for heating, cooling, insulating or housing in advance of placement, adequate to maintain the required temperature and moisture conditions without injury due to concentration of heat.
3. Do not place concrete on frozen ground nor in contact with ice within the forms. Protect concrete from freezing for a period of five days after placing.
4. Stop placing concrete when the quantity of rain falling on the surface is sufficient to wash the concrete surface.
5. Concrete shall have a maximum placing temperature such that it will not cause difficulty from loss of slump, flash set, or cold joints.
6. The temperature of concrete as placed shall not exceed 90o F except that the temperature of concrete placed in walls and slabs three feet or greater in thickness shall not exceed 85o F. When the temperature of the steel is greater than 120o F, embedded items shall be sprayed with water immediately prior to placing concrete.
7. Details and methods of placing and handling concrete during inclement weather shall be in accordance with ACI 305R or ACI 306R as applicable.

### 3.7 PROTECTION FROM AND REMOVAL OF STAINS

- A. Protect the concrete structure from rust staining by structural steel members and from other substances during the work.
- B. If staining does occur, remove stains and restore the concrete to its original color.

### 3.8 DEFECTIVE CONCRETE WORK

- A. Porous areas, open or porous construction joints and honeycombed concrete will be considered to indicate that the requirements for mixing, placing and handling have not been complied with and will be sufficient cause for rejection of the members of the structure thus affected.
- B. Defective work exposed upon removal of forms shall be entirely removed or repaired within forty-eight hours after forms have been removed.
- C. Defective concrete areas not repaired within forty-eight hours after removal of forms shall be patched with polymer-modified mortars and shall be completed by an approved applicator.

- D. Repaired areas will not be accepted if:
  - 1. The structural requirements have been impaired by reducing the net section of compression members;
  - 2. The bond between the steel and concrete has been reduced; and
  - 3. The area is not finished to conform to in every respect to the texture, contour and color of the surrounding concrete.
- E. If the above requirements are not satisfied, the Engineer may require that the members or unit involved be entirely removed and satisfactorily replaced at no additional expense to the owner.

### 3.9 REPAIR OF DEFECTIVE CONCRETE

- A. General: The Engineer will determine the extent and manner of action to be taken for the correction of defective concrete as may be revealed by surface defects or otherwise. Contractor shall submit the repair materials and methods for Engineer's review and approval.
- B. Repair of Formed Surfaces:
  - 1. As soon as possible after stripping forms, thoroughly clean and fill holes left by form ties, and other temporary inserts and perform corrective work.
  - 2. Repair and patch defective areas with cement mortar of mix proportions and materials identical to those used in the surrounding concrete; and produce a finish on the patch that is indistinguishable from the finish of the surrounding concrete, immediately after removing forms, in a manner and by a method accepted by the Engineer in writing prior to start of repair operation.
  - 3. Cut-out honeycomb, rock pockets and voids having a diameter more than 1/2 inch to solid concrete but not shallower than one inch. Make edges of cuts perpendicular to concrete surface. Before placing cement mortar, thoroughly clean, dampen and brush coat areas to be patched with neat cement grout. Proprietary patching compounds may be used if accepted by the Engineer in writing prior to start of repair operation.
  - 4. Remove imperfect texture, laitance, fins and roughness by rubbing affected areas with concrete block or carborundum stone until smooth and uniform.
- C. Repair of Unformed Surfaces:
  - 1. Test unformed surfaces for smoothness and to verify conformance of surface plans to tolerances specified. Correct low and high areas.
  - 2. Test unformed sloped surfaces for trueness of slope and smoothness, using a template having required slope. Correct high and low areas as specified.
  - 3. Repair finished unformed surfaces which contain defects which adversely affect durability of concrete.
  - 4. Grind high areas in unformed surfaces after concrete has cured sufficiently to permit repairs without damaging adjacent areas.

- D. Cut-out low areas in unformed surfaces after completion of surface finishing operations, and replace with fresh concrete. Finish repaired areas to blend into adjacent concrete. Proprietary patching compounds may be used if acceptable to the Engineer.
- E. Cut-out defective areas, except random cracks and single holes not exceeding one inch diameter and replace with fresh concrete. Remove defective areas to sound concrete with clean, square cuts and expose reinforcing steel with at least 3/4 inch clearance all around. Dampen concrete surfaces in contact with patching concrete and brush with neat cement grout coating or use concrete bonding agent. Place patching concrete before grout takes initial set. Mix patching concrete of same materials and in same proportions as adjacent concrete. Place, compact and finish as required to blend with adjacent concrete. Cure in same manner as adjacent concrete.
- F. Repair isolated random cracks and single holes not over an inch in diameter by the dry-pack method. Groove tops of cracks, cut-out holes to sound concrete and remove dust, dirt and loose particles. Dampen cleaned concrete surfaces and brush with neat cement grout coating. Mix dry-pack, consisting of one part portland cement to 2-1/2 parts fine aggregate passing No. 16 sieve, using only enough water for handling and patching. Place dry-pack before grout takes initial set. Compact dry-pack mixture in place and finish to match adjacent concrete. Keep patched areas continuously moist for not less than 72 hours.
- G. Obtain approval of the Engineer before performing repair work other than the removal of imperfect texture, filling of pin holes, holes larger than 3/4 inch wide and insert holes. The Engineer will determine whether the defective area is sufficiently imperfect to warrant rejection of the structural unit.
- H. Repair methods not specified above may be used, subject to acceptance by the Engineer in writing.
- I. Repairs required to the structural components due to the failure of watertightness tests may require specialized material and procedures. These repairs shall be performed by the personnel or contractor qualified in performing those repairs.

**END OF SECTION**

## SECTION 042000 - UNIT MASONRY

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
1. Concrete masonry units.
  2. Decorative concrete masonry units.
  3. Mortar and grout.
  4. Steel reinforcing bars.
  5. Masonry joint reinforcement.
  6. Ties and anchors.
  7. Embedded flashing.
  8. Miscellaneous masonry accessories.

#### 1.2 DEFINITIONS

- A. CMU(s): Concrete masonry unit(s).
- B. Reinforced Masonry: Masonry containing reinforcing steel in grouted cells.

#### 1.3 PERFORMANCE REQUIREMENTS

- A. Provide unit masonry that develops indicated net-area compressive strengths at 28 days.
1. Determine net-area compressive strength of masonry from average net-area compressive strengths of masonry units and mortar types (unit-strength method) according to Tables 1 and 2 in ACI 530.1/ASCE 6/TMS 602.

#### 1.4 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: Contractor will engage a qualified independent testing agency to perform preconstruction testing indicated below. Retesting of materials that fail to comply with specified requirements shall be done at Contractor's expense.
1. Concrete Masonry Unit Test: For each type of unit required, according to ASTM C 140 for compressive strength.
  2. Mortar Test (Property Specification): For each mix required, according to ASTM C 109/C 109M for compressive strength, ASTM C 1506 for water retention, and ASTM C 91 for air content.
  3. Mortar Test (Property Specification): For each mix required, according to ASTM C 780 for compressive strength.

4. Grout Test (Compressive Strength): For each mix required, according to ASTM C 1019.

#### 1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For the following:
  1. Masonry Units: Show sizes, profiles, coursing, and locations of special shapes.
  2. Reinforcing Steel: Detail bending and placement of unit masonry reinforcing bars. Comply with ACI 315, "Details and Detailing of Concrete Reinforcement."
  3. Fabricated Flashing: Detail corner units, end-dam units, and other special applications.
- C. Samples for Initial Selection:
  1. Decorative CMUs, in the form of small-scale units.
  2. Colored mortar.
- D. Samples for Verification: For each type and color of the following:
  1. Decorative CMUs.
  2. Pigmented and colored-aggregate mortar. Make Samples using same sand and mortar ingredients to be used on Project.
  3. Accessories embedded in masonry.

#### 1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Material Certificates: For each type and size of the following:
  1. Masonry units.
    - a. Include material test reports substantiating compliance with requirements.
    - b. For masonry units, include data and calculations establishing average net-area compressive strength of units.
  2. Cementitious materials. Include brand, type, and name of manufacturer.
  3. Preblended, dry mortar mixes. Include description of type and proportions of ingredients.
  4. Grout mixes. Include description of type and proportions of ingredients.
  5. Reinforcing bars.
  6. Joint reinforcement.

7. Anchors, ties, and metal accessories.
- C. Mix Designs: For each type of mortar and grout. Include description of type and proportions of ingredients.
    1. Include test reports for mortar mixes required to comply with property specification. Test according to ASTM C 109/C 109M for compressive strength, ASTM C 1506 for water retention, and ASTM C 91 for air content.
    2. Include test reports, according to ASTM C 1019, for grout mixes required to comply with compressive strength requirement.
  - D. Statement of Compressive Strength of Masonry: For each combination of masonry unit type and mortar type, provide statement of average net-area compressive strength of masonry units, mortar type, and resulting net-area compressive strength of masonry determined according to Tables 1 and 2 in ACI 530.1/ASCE 6/TMS 602.
  - E. Cold-Weather and Hot-Weather Procedures: Detailed description of methods, materials, and equipment to be used to comply with requirements.

#### 1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM C 1093 for testing indicated.
- B. Source Limitations for Masonry Units: Obtain exposed masonry units of a uniform texture and color, or a uniform blend within the ranges accepted for these characteristics, from single source from single manufacturer for each product required.
- C. Source Limitations for Mortar Materials: Obtain mortar ingredients of a uniform quality, including color for exposed masonry, from single manufacturer for each cementitious component and from single source or producer for each aggregate.
- D. Masonry Standard: Comply with ACI 530.1/ASCE 6/TMS 602 unless modified by requirements in the Contract Documents.
- E. Sample Panels: Build sample panels to verify selections made under sample submittals and to demonstrate aesthetic effects.
  1. Build sample panels for each type of exposed unit masonry construction in sizes approximately 48 inches long by 72 inches high by full thickness.
  2. Clean one-half of exposed faces of panels with masonry cleaner indicated.
  3. Protect approved sample panels from the elements with weather-resistant membrane.
  4. Approval of sample panels is for color, texture, and blending of masonry units; relationship of mortar and sealant colors to masonry unit colors;

tooling of joints; aesthetic qualities of workmanship; and other material and construction qualities specifically approved by Architect in writing.

- a. Approval of sample panels does not constitute approval of deviations from the Contract Documents contained in sample panels unless such deviations are specifically approved by Architect in writing.

#### 1.8 DELIVERY, STORAGE, AND HANDLING

- A. Store masonry units on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied. If units become wet, do not install until they are dry.
- B. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.
- C. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.
- D. Deliver preblended, dry mortar mix in moisture-resistant containers designed for use with dispensing silos. Store preblended, dry mortar mix in delivery containers on elevated platforms, under cover, and in a dry location or in covered weatherproof dispensing silos.
- E. Store masonry accessories, including metal items, to prevent corrosion and accumulation of dirt and oil.

#### 1.9 PROJECT CONDITIONS

- A. Protection of Masonry: During construction, cover tops of walls, projections, and sills with waterproof sheeting at end of each day's work. Cover partially completed masonry when construction is not in progress.
  1. Extend cover a minimum of 24 inches down both sides of walls and hold cover securely in place.
  2. Where one wythe of multiwythe masonry walls is completed in advance of other wythes, secure cover a minimum of 24 inches down face next to unconstructed wythe and hold cover in place.
- B. Stain Prevention: Prevent grout, mortar, and soil from staining the face of masonry to be left exposed or painted. Immediately remove grout, mortar, and soil that come in contact with such masonry.
  1. Protect base of walls from rain-splashed mud and from mortar splatter by spreading coverings on ground and over wall surface.
  2. Protect sills, ledges, and projections from mortar droppings.

3. Protect surfaces of window and door frames, as well as similar products with painted and integral finishes, from mortar droppings.
  4. Turn scaffold boards near the wall on edge at the end of each day to prevent rain from splashing mortar and dirt onto completed masonry.
- C. Cold-Weather Requirements: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen substrates. Remove and replace unit masonry damaged by frost or by freezing conditions. Comply with cold-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602.
1. Cold-Weather Cleaning: Use liquid cleaning methods only when air temperature is 40 deg F and higher and will remain so until masonry has dried, but not less than seven days after completing cleaning.
- D. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602.

## **PART 2 - PRODUCTS**

### **2.1 MASONRY UNITS, GENERAL**

- A. Defective Units: Referenced masonry unit standards may allow a certain percentage of units to contain chips, cracks, or other defects exceeding limits stated in the standard. Do not use units where such defects will be exposed in the completed Work.

### **2.2 CONCRETE MASONRY UNITS**

- A. Shapes: Provide shapes indicated and as follows, with exposed surfaces matching exposed faces of adjacent units unless otherwise indicated.
1. Provide special shapes for lintels, corners, jambs, sashes, movement joints, headers, bonding, and other special conditions.
  2. Provide bullnose units for outside corners of interior masonry unless otherwise indicated.
  3. Provide square-edge units for outside corners of exterior veneer masonry unless otherwise indicated.
- B. CMUs: ASTM C 90.
1. Unit Compressive Strength: Provide units with minimum average net-area compressive strength of 2150 psi.
  2. Density Classification: Normal weight.
  3. Size (Width): Manufactured to dimensions 3/8 inch less than nominal dimensions.
  4. Exposed Faces: Provide color and texture matching the range represented by Architect's sample.

- C. Decorative CMUs: ASTM C 90.
1. Products: Subject to compliance with requirements, provide the following, or approved equal:
    - a. Trenwyth Industries; Trendstone Plus filled and polished ground face masonry units.
  2. Unit Compressive Strength: Provide units with minimum average net-area compressive strength of 2150 psi
  3. Density Classification: Normal weight.
  4. Size (Width): Manufactured to dimensions specified in "CMUs" Paragraph.
  5. Pattern and Texture:
    - a. Standard pattern, ground-face finish.
  6. Colors:
    - a. CMU-1: Trendstone Plus "Alamo", or approved equal.
    - b. CMU-2: Trendstone Plus "Williamsburg Grey", or approved equal.
    - c. CMU-3: Trendstone Plus "Natural", or approved equal.

### 2.3 MORTAR AND GROUT MATERIALS

- A. Portland Cement: ASTM C 150, Type I or II, except Type III may be used for cold-weather construction. Provide natural color or white cement as required to produce mortar color indicated.
- B. Hydrated Lime: ASTM C 207, Type S.
- C. Portland Cement-Lime Mix: Packaged blend of portland cement and hydrated lime containing no other ingredients.
- D. Masonry Cement: ASTM C 91.
- E. Mortar Cement: ASTM C 1329.
- F. Mortar Pigments: Natural and synthetic iron oxides and chromium oxides, compounded for use in mortar mixes and complying with ASTM C 979. Use only pigments with a record of satisfactory performance in masonry mortar.
- G. Colored Cement Product: Packaged blend made from portland cement and hydrated lime and mortar pigments, all complying with specified requirements, and containing no other ingredients.
  1. Colored Portland Cement-Lime Mix:

- a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
  - 1) Capital Materials Corporation; Riverton Portland Cement Lime Custom Color.
  - 2) Holcim (US) Inc.; Rainbow Mortamix Custom Color Cement/Lime.
  - 3) Lafarge North America Inc.; Eaglebond Portland & Lime.
  - 4) Lehigh Cement Company; Lehigh Custom Color Portland/Lime Cement.
2. Colored Masonry Cement:
  - a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
    - 1) Capital Materials Corporation; Flamingo Color Masonry Cement.
    - 2) Cemex S.A.B. de C.V.; Richcolor Masonry Cement.
    - 3) Essroc, Italcementi Group; Brixment-in-Color.
    - 4) Holcim (US) Inc.; Rainbow Mortamix Custom Color Masonry Cement.
    - 5) Lafarge North America Inc.; U.S. Cement Custom Color Masonry Cement.
    - 6) Lehigh Cement Company; Lehigh Custom Color Masonry Cement.
    - 7) National Cement Company, Inc.; Coosa Masonry Cement.
  3. Formulate blend as required to produce color indicated or, if not indicated, as selected from manufacturer's standard colors.
  4. Pigments shall not exceed 10 percent of portland cement by weight.
  5. Pigments shall not exceed 5 percent of mortar cement by weight.
- H. Aggregate for Mortar: ASTM C 144.
  1. For mortar that is exposed to view, use washed aggregate consisting of natural sand or crushed stone.
  2. For joints less than 1/4 inch thick, use aggregate graded with 100 percent passing the No. 16 sieve.
  3. White-Mortar Aggregates: Natural white sand or crushed white stone.
  4. Colored-Mortar Aggregates: Natural sand or crushed stone of color necessary to produce required mortar color.
- I. Aggregate for Grout: ASTM C 404.

- J. Cold-Weather Admixture: Nonchloride, noncorrosive, accelerating admixture complying with ASTM C 494/C 494M, Type C, and recommended by manufacturer for use in masonry mortar of composition indicated.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
    - a. Euclid Chemical Company (The); Accelguard 80.
    - b. Grace Construction Products, W. R. Grace & Co. - Conn.; Morset.
    - c. Sonneborn Products, BASF Aktiengesellschaft; Trimix-NCA.
- K. Water-Repellent Admixture: Liquid water-repellent mortar admixture intended for use with CMUs containing integral water repellent by same manufacturer.
1. Products: Subject to compliance with requirements, [available products that may be incorporated into the Work include, but are not limited to, the following:
    - a. ACM Chemistries; RainBloc for Mortar.
    - b. BASF Aktiengesellschaft; Rheopel Mortar Admixture.
    - c. Grace Construction Products, W. R. Grace & Co. - Conn.; Dry-Block Mortar Admixture.
- L. Water: Potable.

## 2.4 REINFORCEMENT

- A. Uncoated Steel Reinforcing Bars: ASTM A 615/A 615M or ASTM A 996/A 996M, Grade 60.
- B. Masonry Joint Reinforcement, General: ASTM A 951/A 951M.
1. Interior Walls: Hot-dip galvanized, carbon steel.
  2. Exterior Walls: Hot-dip galvanized, carbon steel.
  3. Wire Size for Side Rods: 0.187-inch diameter.
  4. Wire Size for Cross Rods: 0.148-inch diameter.
  5. Wire Size for Veneer Ties: 0.187-inch diameter.
  6. Spacing of Cross Rods, Tabs, and Cross Ties: Not more than 16 inches o.c.
  7. Provide in lengths of not less than 10 feet, with prefabricated corner and tee units.
- C. Masonry Joint Reinforcement for Single-Wythe Masonry: Either ladder or truss type with single pair of side rods.
- D. Masonry Joint Reinforcement for Multiwythe Masonry:

1. Adjustable (two-piece) type, either ladder or truss design, with one side rod at each face shell of backing wythe and with separate adjustable ties with pintle-and-eye connections having a maximum adjustment of 1-1/4 inches. Size ties to extend at least halfway through facing wythe but with at least 5/8-inch cover on outside face. Ties have hooks or clips to engage a continuous horizontal wire in the facing wythe.

## 2.5 TIES AND ANCHORS

- A. Materials: Provide ties and anchors specified in this article that are made from materials that comply with the following unless otherwise indicated.
  1. Hot-Dip Galvanized, Carbon-Steel Wire: ASTM A 82/A 82M; with ASTM A 153/A 153M, Class B-2 coating.
  2. Steel Sheet, Galvanized after Fabrication: ASTM A 1008/A 1008M, Commercial Steel, with ASTM A 153/A 153M, Class B coating.
  3. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
- B. Wire Ties, General: Unless otherwise indicated, size wire ties to extend at least halfway through veneer but with at least 5/8-inch cover on outside face. Outer ends of wires are bent 90 degrees and extend 2 inches parallel to face of veneer.
- C. Adjustable Masonry-Veneer Anchors:
  1. General: Provide anchors that allow vertical adjustment but resist tension and compression forces perpendicular to plane of wall, for attachment over sheathing to wood or metal studs, and as follows:
    - a. Structural Performance Characteristics: Capable of withstanding a 100-lbf load in both tension and compression without deforming or developing play in excess of 0.05 inch.
  2. Fabricate sheet metal anchor sections and other sheet metal parts from 1.05-inch- thick steel sheet, galvanized after fabrication.
  3. Wire Ties: Triangular-, rectangular-, or T-shaped wire ties fabricated from 0.187-inch- diameter, hot-dip galvanized-steel wire unless otherwise indicated.
  4. Screw-Attached, Masonry-Veneer Anchors: Units consisting of a wire tie and a metal anchor section.
    - a. Products: Subject to compliance with requirements, provide the following or an approved equal:
      - 1) Hohmann & Barnard, Inc.; 2-Seal Tie Veneer Anchor
    - b. Anchor Section: Dual-barrel single screw consisting of an integrated self-drilling screw for attachment to metal studs and two barrels each with a washer to seal tight against exterior sheathing and insulation.

## 2.6 MISCELLANEOUS ANCHORS

- A. Postinstalled Anchors: Torque-controlled expansion anchors or chemical anchors.
  - 1. Load Capacity: Capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E 488, conducted by a qualified independent testing agency.
  - 2. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B 633 or ASTM F 1941, Class Fe/Zn 5 unless otherwise indicated.
  - 3. Material for Exterior Locations and Where Stainless Steel Is Indicated: Alloy Group 1 or Group 2 stainless-steel bolts, ASTM F 593, and nuts, ASTM F 594.

## 2.7 EMBEDDED FLASHING MATERIALS

- A. Metal Flashing: Provide metal flashing complying with Section 076200 "Sheet Metal Flashing and Trim" and as follows:
- B. Flexible Flashing: Use the following unless otherwise indicated:
  - 1. Rubberized-Asphalt Flashing: Composite flashing product consisting of a pliable, adhesive rubberized-asphalt compound, bonded to a high-density, cross-laminated polyethylene film to produce an overall thickness of not less than 0.040 inch.
    - a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      - 1) Grace Construction Products, W. R. Grace & Co. - Conn.; Perm-A-Barrier Wall Flashing.
    - b. Accessories: Provide preformed corners, end dams, other special shapes, and seaming materials produced by flashing manufacturer.
    - c. Air Barrier Compatibility: Flexible and through-wall flashings shall be compatible with fluid-applied, vapor-permeable air barrier system.
- C. Application: Unless otherwise indicated, use the following:
  - 1. Where flashing is indicated to receive counterflashing, use metal flashing.
  - 2. Where flashing is partly exposed and is indicated to terminate at the wall face flexible flashing with a metal sealant stop.
  - 3. Where flashing is fully concealed, use flexible flashing.

- D. Solder and Sealants for Sheet Metal Flashings: As specified in Section 076200 "Sheet Metal Flashing and Trim."
- E. Adhesives, Primers, and Seam Tapes for Flashings: Flashing manufacturer's standard products or products recommended by flashing manufacturer for bonding flashing sheets to each other and to substrates.

## 2.8 MISCELLANEOUS MASONRY ACCESSORIES

- A. Compressible Filler: Premolded filler strips complying with ASTM D 1056, Grade 2A1; compressible up to 35 percent; of width and thickness indicated; formulated from neoprene urethane or PVC.
- B. Preformed Control-Joint Gaskets: Made from styrene-butadiene-rubber compound, complying with ASTM D 2000, Designation M2AA-805 or PVC, complying with ASTM D 2287, Type PVC-65406 and designed to fit standard sash block and to maintain lateral stability in masonry wall; size and configuration as indicated.
- C. Bond-Breaker Strips: Asphalt-saturated, organic roofing felt complying with ASTM D 226, Type I (No. 15 asphalt felt).
- D. Reinforcing Bar Positioners: Wire units designed to fit into mortar bed joints spanning masonry unit cells and hold reinforcing bars in center of cells. Units are formed from 0.148-inch steel wire, hot-dip galvanized after fabrication. Provide units designed for number of bars indicated.

## 2.9 MASONRY CLEANERS

- A. Proprietary Acidic Cleaner: Manufacturer's standard-strength cleaner designed for removing mortar/grout stains, efflorescence, and other new construction stains from new masonry without discoloring or damaging masonry surfaces. Use product expressly approved for intended use by cleaner manufacturer and manufacturer of masonry units being cleaned.
  - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - a. Diedrich Technologies, Inc.
    - b. EaCo Chem, Inc.
    - c. ProSoCo, Inc.

## 2.10 MORTAR AND GROUT MIXES

- A. General: Do not use admixtures, including pigments, air-entraining agents, accelerators, retarders, water-repellent agents, antifreeze compounds, or other admixtures, unless otherwise indicated.

1. Do not use calcium chloride in mortar or grout.
  2. Use portland cement-lime, masonry cement or mortar cement mortar unless otherwise indicated.
  3. For exterior masonry, use portland cement-lime, masonry cement or mortar cement mortar.
  4. For reinforced masonry, use portland cement-lime, masonry cement or mortar cement mortar.
  5. Add cold-weather admixture (if used) at same rate for all mortar that will be exposed to view, regardless of weather conditions, to ensure that mortar color is consistent.
- B. Preblended, Dry Mortar Mix: Furnish dry mortar ingredients in form of a preblended mix. Measure quantities by weight to ensure accurate proportions, and thoroughly blend ingredients before delivering to Project site.
- C. Mortar for Unit Masonry: Comply with ASTM C 270, Property Specification. Provide the following types of mortar for applications stated unless another type is indicated.
1. For masonry below grade or in contact with earth, use Type M or Type S.
  2. For reinforced masonry, use Type S.
  3. For exterior, above-grade, load-bearing and non-load-bearing walls and parapet walls; for interior load-bearing walls; for interior non-load-bearing partitions; and for other applications where another type is not indicated, use Type N.
  4. For interior non-load-bearing partitions, Type O may be used instead of Type N.
- D. Pigmented Mortar: Use colored cement product or select and proportion pigments with other ingredients to produce color required. Do not add pigments to colored cement products.
1. Pigments shall not exceed 10 percent of portland cement by weight.
  2. Pigments shall not exceed 5 percent of masonry cement or mortar cement by weight.
  3. As selected by Architect from manufacturer's full range of colors.
  4. Application: Use pigmented mortar for exposed mortar joints with the following units:
    - a. Decorative CMUs.
- E. Grout for Unit Masonry: Comply with ASTM C 476.
1. Use grout of type indicated or, if not otherwise indicated, of type (fine or coarse) that will comply with Table 1.15.1 in ACI 530.1/ASCE 6/TMS 602 for dimensions of grout spaces and pour height.

2. Proportion grout in accordance with ASTM C 476, Table 1 or paragraph 4.2.2 for specified 28-day compressive strength indicated, but not less than 2000 psi.
3. Provide grout with a slump of 8 to 11 inches as measured according to ASTM C 143/C 143M.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
  1. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of work.
  2. Verify that foundations are within tolerances specified.
  3. Verify that reinforcing dowels are properly placed.
- B. Before installation, examine rough-in and built-in construction for piping systems to verify actual locations of piping connections.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.2 INSTALLATION, GENERAL**

- A. Thickness: Build cavity and composite walls and other masonry construction to full thickness shown. Build single-wythe walls to actual widths of masonry units, using units of widths indicated.
- B. Build chases and recesses to accommodate items specified in this and other Sections.
- C. Leave openings for equipment to be installed before completing masonry. After installing equipment, complete masonry to match the construction immediately adjacent to opening.
- D. Use full-size units without cutting if possible. If cutting is required to provide a continuous pattern or to fit adjoining construction, cut units with motor-driven saws; provide clean, sharp, unchipped edges. Allow units to dry before laying unless wetting of units is specified. Install cut units with cut surfaces and, where possible, cut edges concealed.
- E. Select and arrange units for exposed unit masonry to produce a uniform blend of colors and textures.
  1. Mix units from several pallets or cubes as they are placed.

### 3.3 TOLERANCES

#### A. Dimensions and Locations of Elements:

1. For dimensions in cross section or elevation do not vary by more than plus 1/2 inch or minus 1/4 inch.
2. For location of elements in plan do not vary from that indicated by more than plus or minus 1/2 inch.
3. For location of elements in elevation do not vary from that indicated by more than plus or minus 1/4 inch in a story height or 1/2 inch total.

#### B. Lines and Levels:

1. For bed joints and top surfaces of bearing walls do not vary from level by more than 1/4 inch in 10 feet, or 1/2 inch maximum.
2. For conspicuous horizontal lines, such as lintels, sills, parapets, and reveals, do not vary from level by more than 1/8 inch in 10 feet, 1/4 inch in 20 feet, or 1/2 inch maximum.
3. For vertical lines and surfaces do not vary from plumb by more than 1/4 inch in 10 feet, 3/8 inch in 20 feet, or 1/2 inch maximum.
4. For conspicuous vertical lines, such as external corners, door jambs, reveals, and expansion and control joints, do not vary from plumb by more than 1/8 inch in 10 feet, 1/4 inch in 20 feet, or 1/2 inch maximum.
5. For lines and surfaces do not vary from straight by more than 1/4 inch in 10 feet, 3/8 inch in 20 feet, or 1/2 inch maximum.
6. For vertical alignment of exposed head joints, do not vary from plumb by more than 1/4 inch in 10 feet, or 1/2 inch maximum.
7. For faces of adjacent exposed masonry units, do not vary from flush alignment by more than 1/16 inch except due to warpage of masonry units within tolerances specified for warpage of units.

#### C. Joints:

1. For bed joints, do not vary from thickness indicated by more than plus or minus 1/8 inch, with a maximum thickness limited to 1/2 inch.
2. For exposed bed joints, do not vary from bed-joint thickness of adjacent courses by more than 1/8 inch.
3. For head and collar joints, do not vary from thickness indicated by more than plus 3/8 inch or minus 1/4 inch.
4. For exposed head joints, do not vary from thickness indicated by more than plus or minus 1/8 inch. Do not vary from adjacent bed-joint and head-joint thicknesses by more than 1/8 inch.

### 3.4 LAYING MASONRY WALLS

- #### A.
- Lay out walls in advance for accurate spacing of surface bond patterns with uniform joint thicknesses and for accurate location of openings, movement-type

joints, returns, and offsets. Avoid using less-than-half-size units, particularly at corners, jambs, and, where possible, at other locations.

- B. Bond Pattern for Exposed Masonry: Unless otherwise indicated, lay exposed masonry in running bond; do not use units with less than nominal 4-inch horizontal face dimensions at corners or jambs.
- C. Stopping and Resuming Work: Stop work by racking back units in each course from those in course below; do not tooth. When resuming work, clean masonry surfaces that are to receive mortar, remove loose masonry units and mortar, and wet brick if required before laying fresh masonry.
- D. Built-in Work: As construction progresses, build in items specified in this and other Sections. Fill in solidly with masonry around built-in items.
- E. Fill space between steel frames and masonry solidly with mortar unless otherwise indicated.
- F. Where built-in items are to be embedded in cores of hollow masonry units, place a layer of metal lath, wire mesh, or plastic mesh in the joint below and rod mortar or grout into core.
- G. Fill cores in hollow CMUs with grout 24 inches under bearing plates, beams, lintels, posts, and similar items unless otherwise indicated.
- H. Build non-load-bearing interior partitions full height of story to underside of solid floor or roof structure above unless otherwise indicated.

### 3.5 MORTAR BEDDING AND JOINTING

- A. Lay hollow CMUs as follows:
  - 1. With face shells fully bedded in mortar and with head joints of depth equal to bed joints.
  - 2. With webs fully bedded in mortar in all courses of piers, columns, and pilasters.
  - 3. With webs fully bedded in mortar in grouted masonry, including starting course on footings.
  - 4. With entire units, including areas under cells, fully bedded in mortar at starting course on footings where cells are not grouted.
- B. Lay solid masonry units with completely filled bed and head joints; butter ends with sufficient mortar to fill head joints and shove into place. Do not deeply furrow bed joints or slush head joints.
- C. Tool exposed joints slightly concave when thumbprint hard, using a jointer larger than joint thickness unless otherwise indicated.

### 3.6 MASONRY JOINT REINFORCEMENT

- A. General: Install entire length of longitudinal side rods in mortar with a minimum cover of 5/8 inch on exterior side of walls, 1/2 inch elsewhere. Lap reinforcement a minimum of 6 inches.
  - 1. Space reinforcement not more than 16 inches o.c.
  - 2. Space reinforcement not more than 8 inches o.c. in foundation walls and parapet walls.
  - 3. Provide reinforcement not more than 8 inches above and below wall openings and extending 12 inches beyond openings.
- B. Interrupt joint reinforcement at control and expansion joints unless otherwise indicated.
- C. Provide continuity at wall intersections by using prefabricated T-shaped units.
- D. Provide continuity at corners by using prefabricated L-shaped units.
- E. Cut and bend reinforcing units as directed by manufacturer for continuity at returns, offsets, column fireproofing, pipe enclosures, and other special conditions.

### 3.7 REINFORCED UNIT MASONRY INSTALLATION

- A. Temporary Formwork and Shores: Construct formwork and shores as needed to support reinforced masonry elements during construction.
  - 1. Construct formwork to provide shape, line, and dimensions of completed masonry as indicated. Make forms sufficiently tight to prevent leakage of mortar and grout. Brace, tie, and support forms to maintain position and shape during construction and curing of reinforced masonry.
  - 2. Do not remove forms and shores until reinforced masonry members have hardened sufficiently to carry their own weight and other loads that may be placed on them during construction.
- B. Placing Reinforcement: Comply with requirements in ACI 530.1/ASCE 6/TMS 602.
- C. Grouting: Do not place grout until entire height of masonry to be grouted has attained enough strength to resist grout pressure.
  - 1. Comply with requirements in ACI 530.1/ASCE 6/TMS 602 for cleanouts and for grout placement, including minimum grout space and maximum pour height.
  - 2. Limit height of vertical grout pours to not more than 60 inches.

### 3.8 FIELD QUALITY CONTROL

- A. Testing and Inspecting: Engage inspectors to perform tests and inspections and prepare reports. Allow inspectors access to scaffolding and work areas, as needed to perform tests and inspections. Retesting of materials that fail to comply with specified requirements shall be done at Contractor's expense.
- B. Inspections:
  - 1. Begin masonry construction only after inspectors have verified proportions of site-prepared mortar.
  - 2. Place grout only after inspectors have verified compliance of grout spaces and of grades, sizes, and locations of reinforcement.
  - 3. Place grout only after inspectors have verified proportions of site-prepared grout.
- C. Testing Prior to Construction: One set of tests.
- D. Testing Frequency: One set of tests for each 5000 sq. ft. of wall area or portion thereof.
- E. Concrete Masonry Unit Test: For each type of unit provided, according to ASTM C 140 for compressive strength.
- F. Mortar Aggregate Ratio Test (Proportion Specification): For each mix provided, according to ASTM C 780.
- G. Mortar Test (Property Specification): For each mix provided, according to ASTM C 780. Test mortar for mortar air content and compressive strength.
- H. Grout Test (Compressive Strength): For each mix provided, according to ASTM C 1019.

### 3.9 REPAIRING, POINTING, AND CLEANING

- A. Remove and replace masonry units that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Install new units to match adjoining units; install in fresh mortar, pointed to eliminate evidence of replacement.
- B. Pointing: During the tooling of joints, enlarge voids and holes, except weep holes, and completely fill with mortar. Point up joints, including corners, openings, and adjacent construction, to provide a neat, uniform appearance. Prepare joints for sealant application, where indicated.
- C. In-Progress Cleaning: Clean unit masonry as work progresses by dry brushing to remove mortar fins and smears before tooling joints.

- D. Final Cleaning: After mortar is thoroughly set and cured, clean exposed masonry as follows:
1. Remove large mortar particles by hand with wooden paddles and nonmetallic scrape hoes or chisels.
  2. Test cleaning methods on sample wall panel; leave one-half of panel uncleaned for comparison purposes. Obtain Architect's approval of sample cleaning before proceeding with cleaning of masonry.
  3. Protect adjacent nonmasonry surfaces from contact with cleaner by covering them with liquid strippable masking agent or polyethylene film and waterproof masking tape.
  4. Wet wall surfaces with water before applying cleaners; remove cleaners promptly by rinsing surfaces thoroughly with clear water.
  5. Clean masonry with a proprietary acidic cleaner applied according to manufacturer's written instructions.
  6. Clean concrete masonry by cleaning method indicated in NCMA TEK 8-2A applicable to type of stain on exposed surfaces.

### 3.10 MASONRY WASTE DISPOSAL

- A. Salvageable Materials: Unless otherwise indicated, excess masonry materials are Contractor's property. At completion of unit masonry work, remove from Project site.
- B. Excess Masonry Waste: Remove excess clean masonry waste and legally dispose of off Owner's property.

**END OF SECTION**

## **SECTION 055000 - METAL FABRICATIONS**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

- A. Section Includes:
  - 1. Steel framing and supports for mechanical and electrical equipment.
  - 2. Steel framing and supports for applications where framing and supports are not specified in other Sections.
  - 3. Loose bearing and leveling plates for applications where they are not specified in other Sections.
- B. Related Requirements:
  - 1. Section 042000 "Unit Masonry" for installing loose lintels, anchor bolts, and other items built into unit masonry.

#### **1.2 COORDINATION**

- A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.
- B. Coordinate installation of metal fabrications that are anchored to or that receive other work. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

#### **1.3 ACTION SUBMITTALS**

- A. Shop Drawings: Show fabrication and installation details. Include details of metal fabrications and their connections. Show anchorage and accessory items. Provide Shop Drawings for the following:
  - 1. Steel framing and supports for mechanical and electrical equipment.
  - 2. Steel framing and supports for applications where framing and supports are not specified in other Sections.

#### **1.4 INFORMATIONAL SUBMITTALS**

- A. Mill Certificates: Signed by stainless-steel manufacturers, certifying that products furnished comply with requirements.
- B. Welding certificates.
- C. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers, certifying that shop primers are compatible with topcoats.

## 1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Welding Qualifications: Qualify procedures and personnel according to the following:
  - 1. AWS D1.6/D1.6M, "Structural Welding Code - Stainless Steel."

## 1.6 FIELD CONDITIONS

- A. Field Measurements: Verify actual locations of walls and other construction contiguous with metal fabrications by field measurements before fabrication.

## **PART 2 - PRODUCTS**

### 2.1 PERFORMANCE REQUIREMENTS

- A. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes acting on exterior metal fabrications by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects.
  - 1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

### 2.2 METALS

- A. Metal Surfaces, General: Provide materials with smooth, flat surfaces unless otherwise indicated. For metal fabrications exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.
- B. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.
- C. Stainless-Steel Sheet, Strip, and Plate: ASTM A 240/A 240M or ASTM A 666, Type 304 .
- D. Stainless-Steel Bars and Shapes: ASTM A 276, Type 304 .

### 2.3 FASTENERS

- A. General: Unless otherwise indicated, provide Type 304 stainless-steel fasteners for exterior use and zinc-plated fasteners with coating complying with ASTM B 633 or ASTM F 1941, Class Fe/Zn 5, at exterior walls. Select fasteners for type, grade, and class required.
  - 1. Provide stainless-steel fasteners for fastening aluminum.

2. Provide stainless-steel fasteners for fastening stainless steel.
- B. Steel Bolts and Nuts: Regular hexagon-head bolts, ASTM A 307, Grade A; with hex nuts, ASTM A 563; and, where indicated, flat washers.
  - C. Steel Bolts and Nuts: Regular hexagon-head bolts, ASTM A 325, Type 3; with hex nuts, ASTM A 563, Grade C3; and, where indicated, flat washers.
  - D. Stainless-Steel Bolts and Nuts: Regular hexagon-head annealed stainless-steel bolts, ASTM F 593; with hex nuts, ASTM F 594; and, where indicated, flat washers; Alloy Group 1\or Group 2.
  - E. Anchor Bolts: ASTM F 1554, Grade 36, of dimensions indicated; with nuts, ASTM A 563; and, where indicated, flat washers.
    1. Hot-dip galvanize or provide mechanically deposited, zinc coating where item being fastened is indicated to be galvanized.
  - F. Anchors, General: Anchors capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E 488/E 488M, conducted by a qualified independent testing agency.
  - G. Cast-in-Place Anchors in Concrete: Either threaded type or wedge type unless otherwise indicated; galvanized ferrous castings, either ASTM A 47/A 47M malleable iron or ASTM A 27/A 27M cast steel. Provide bolts, washers, and shims as needed, all hot-dip galvanized per ASTM F 2329.
  - H. Post-Installed Anchors: Torque-controlled expansion anchors or chemical anchors.
    1. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B 633 or ASTM F 1941, Class Fe/Zn 5, unless otherwise indicated.
    2. Material for Exterior Locations and Where Stainless Steel Is Indicated: Alloy Group 1 or Group 2 stainless-steel bolts, ASTM F 593, and nuts, ASTM F 594.

#### 2.4 MISCELLANEOUS MATERIALS

- A. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187/D 1187M.
- B. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107/C 1107M. Provide grout specifically recommended by manufacturer for interior and exterior applications.

## 2.5 FABRICATION, GENERAL

- A. Shop Assembly: Preassemble items in the shop to greatest extent possible. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.
- B. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
- C. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
- D. Form exposed work with accurate angles and surfaces and straight edges.
- E. Weld corners and seams continuously to comply with the following:
  - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
  - 2. Obtain fusion without undercut or overlap.
  - 3. Remove welding flux immediately.
  - 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- F. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners or welds where possible. Where exposed fasteners are required, use Phillips flat-head (countersunk) fasteners unless otherwise indicated. Locate joints where least conspicuous.
- G. Fabricate seams and other connections that are exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.
- H. Cut, reinforce, drill, and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.
- I. Provide for anchorage of type indicated; coordinate with supporting structure. Space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.
- J. Where units are indicated to be cast into concrete or built into masonry, equip with integrally welded steel strap anchors, 1/8 by 1-1/2 inches, with a minimum 6-inch embedment and 2-inch hook, not less than 8 inches from ends and corners of units and 24 inches o.c., unless otherwise indicated.

## 2.6 MISCELLANEOUS FRAMING AND SUPPORTS

- A. General: Provide steel framing and supports not specified in other Sections as needed to complete the Work.
- B. Fabricate units from steel shapes, plates, and bars of welded construction unless otherwise indicated. Fabricate to sizes, shapes, and profiles indicated and as necessary to receive adjacent construction.
  - 1. Fabricate units from slotted channel framing where indicated.
  - 2. Furnish inserts for units installed after concrete is placed.

## 2.7 MISCELLANEOUS STEEL

- A. Unless otherwise indicated, fabricate units from steel shapes, plates, and bars of profiles shown with continuously welded joints and smooth exposed edges. Miter corners and use concealed field splices where possible.
- B. Provide cutouts, fittings, and anchorages as needed to coordinate assembly and installation with other work.
  - 1. Provide with integrally welded steel strap anchors for embedding in concrete or masonry construction.

## 2.8 LOOSE BEARING AND LEVELING PLATES

- A. Provide loose bearing and leveling plates for steel items bearing on masonry or concrete construction. Drill plates to receive anchor bolts and for grouting.

## 2.9 FINISHES, GENERAL

- A. Finish metal fabrications after assembly.
- B. Finish exposed surfaces to remove tool and die marks and stretch lines, and to blend into surrounding surface.

# **PART 3 - EXECUTION**

## 3.1 INSTALLATION, GENERAL

- A. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.
- B. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of

exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.

- C. Field Welding: Comply with the following requirements:
1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
  2. Obtain fusion without undercut or overlap.
  3. Remove welding flux immediately.
  4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- D. Fastening to In-Place Construction: Provide anchorage devices and fasteners where metal fabrications are required to be fastened to in-place construction. Provide threaded fasteners for use with concrete and masonry inserts, toggle bolts, through bolts, lag screws, wood screws, and other connectors.
- E. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.

### 3.2 INSTALLING MISCELLANEOUS FRAMING AND SUPPORTS

- A. General: Install framing and supports to comply with requirements of items being supported, including manufacturers' written instructions and requirements indicated on Shop Drawings.

### 3.3 INSTALLING BEARING AND LEVELING PLATES

- A. Clean concrete and masonry bearing surfaces of bond-reducing materials, and roughen to improve bond to surfaces. Clean bottom surface of plates.
- B. Set bearing and leveling plates on wedges, shims, or leveling nuts. After bearing members have been positioned and plumbed, tighten anchor bolts. Do not remove wedges or shims but, if protruding, cut off flush with edge of bearing plate before packing with nonshrink grout. Pack grout solidly between bearing surfaces and plates to ensure that no voids remain.

**END OF SECTION**

## SECTION 101400 - SIGNAGE

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes the following:
  - 1. Project Identification signs.
  - 2. Dimensional Letter signage.
- B. Related Sections include the following:
  - 1. Standard Specifications for exterior signage other than Dimensional Letter signage.
  - 2. Section ~~132000~~—131200 "Modular Restrooms" for toilet room identification with pre-fabricated toilet room building.
  - 3. Division 26 Section "Electrical Identification" for labels, tags, and nameplates for electrical equipment.

#### 1.2 DEFINITIONS

- A. ADA-ABA Accessibility Guidelines: U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Architectural Barriers Act (ABA) Accessibility Guidelines." Comply with all additional requirements of the Delaware Architectural Accessibility Standards.

#### 1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Show fabrication and installation details for signs.
  - 1. Show sign mounting heights, locations of supplementary supports to be provided by others, and accessories.
  - 2. Provide message list, typestyles, graphic elements and layout for each sign.
- C. Samples for Initial Selection: For each type of sign assembly, exposed component, and exposed finish.
  - 1. Include representative Samples of typestyles and graphic symbols.
- D. Samples for Verification: For each type of sign assembly showing all components and with the required finishes, in manufacturer's standard size unless otherwise indicated and as follows:

1. Dimensional Characters: Half-size sample of each type of dimensional character.

E. Sign Schedule: Use same designations indicated on Drawings.

#### 1.4 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of signs that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
  - a. Deterioration of finishes beyond normal weathering.
  - b. Separation or delamination of sheet materials and components.
2. Warranty Period: Five years from date of Substantial Completion.

#### 1.5 COORDINATION

A. Coordinate placement of anchorage devices with templates for installing signs.

### **PART 2 - PRODUCTS**

#### 2.1 MATERIALS

A. Bronze Castings: ASTM B 584, Alloy UNS No. C86500 (No. 1 manganese bronze).

#### 2.2 PROJECT IDENTIFICATION SIGNS

A. FTA Project Sign:

1. Material: 3/4-inch thick, 5-ply exterior A-B grade plywood. Posts shall be 4-inch by 6-inch construction grade lumber, pressure-preservative treated, 10 feet long.
2. Text and Graphics: As indicated in Figure 1 at the end of Part 3.
3. Finish: Two coats of semi-gloss enamel over compatible primer.

#### 2.3 DIMENSIONAL CHARACTERS

A. Cast Characters: Characters with uniform faces, sharp corners, and precisely formed lines and profiles as follows:

1. Character Material: Cast bronze.
2. Thickness: Manufacturer's standard for size of character.
3. Finishes:
  - a. Integral Metal Finish: Manufacturer's standard medium bronze.
4. Mounting: Projecting studs.

5. Typeface: Future Demi-bold

B. Landscaped Site Sign:

1. Character Heights: As indicated on Drawings.
2. Text: LEWES TRANSIT CENTER

## 2.4 ACCESSORIES

A. Anchors and Inserts: Provide nonferrous-metal or hot-dip galvanized anchors and inserts for exterior installations and elsewhere as required for corrosion resistance. Use toothed steel or lead expansion-bolt devices for drilled-in-place anchors. Furnish inserts, as required, to be set into concrete or masonry work.

## 2.5 FABRICATION

A. General: Provide manufacturer's standard signs of configurations indicated.

1. Welded Connections: Comply with AWS standards for recommended practices in shop welding. Provide welds behind finished surfaces without distortion or discoloration of exposed side. Clean exposed welded surfaces of welding flux and dress exposed and contact surfaces.
2. Mill joints to tight, hairline fit. Form joints exposed to weather to exclude water penetration.
3. Preassemble signs in the shop to greatest extent possible. Disassemble signs only as necessary for shipping and handling limitations. Clearly mark units for reassembly and installation, in location not exposed to view after final assembly.
4. Conceal fasteners if possible; otherwise, locate fasteners where they will be inconspicuous.

## 2.6 FINISHES, GENERAL

- A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
- B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- C. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

## 2.7 COPPER-ALLOY FINISHES

- A. Cast-Bronze Finishes: Exposed surfaces free of porosity, burrs, and rough spots; with returns finished with fine-grain air blast.
  - 1. Raised Areas: Hand-tool and buff borders and raised copy to produce manufacturer's standard satin finish.
  - 2. Background Finish: Dark oxidized.
- B. Clear Protective Coating: Coat exposed surfaces of copper alloys with manufacturer's standard, clear organic coating specially designed for coating copper-alloy products.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of work.
- B. Verify that items are sized and located to accommodate signs.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Locate signs and accessories where indicated, using mounting methods of types described and complying with manufacturer's written instructions.
  - 1. Install signs level, plumb, and at heights indicated, with sign surfaces free of distortion and other defects in appearance.
  - 2. Interior Wall Signs: Install signs on walls adjacent to latch side of door where applicable. Where not indicated or possible, such as double doors, install signs on nearest adjacent walls. Locate to allow approach within 3 inches of sign without encountering protruding objects or standing within swing of door.
- B. Wall-Mounted Signs: Comply with sign manufacturer's written instructions except where more stringent requirements apply.
  - 1. Two-Face Tape: Mount signs to smooth, nonporous surfaces. Do not use this method for vinyl-covered or rough surfaces.
- C. Bracket-Mounted Signs: Provide manufacturer's standard brackets, fittings, and hardware for mounting signs that project at right angles from walls and ceilings. Attach brackets and fittings securely to walls and ceilings with concealed

fasteners and anchoring devices to comply with manufacturer's written instructions.

3.3 CLEANING AND PROTECTION

- A. After installation, clean soiled sign surfaces according to manufacturer's written instructions. Protect signs from damage until acceptance by Owner.

3.4 REQUIRED SIGNS

- A. FTA Project Sign: As indicated in Figure 1 below.
- B. Landscaped Site Sign: As indicated on Landscape Drawings.

Figure 1

END OF SECTION

## **SECTION 107343 - TRANSPORTATION STOP SHELTERS**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

- A. Section Includes:
  - 1. Wood-framed shelters.

#### **1.2 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for shelters.
- B. Shop Drawings: For shelters. Include plans, elevations, sections, details, and attachments to other work.
  - 1. Anchor-Bolt Plans: Submit anchor-bolt plans and templates. Include location, diameter, and projection of anchor bolts required to attach shelters to concrete bases. Indicate post reactions at each location.
- C. Samples for Initial Selection: For each type of exposed finish.

#### **1.3 INFORMATION SUBMITTALS**

- A. Structural Calculations: Provide manufacturer's documentation indicating structural loads that the assembled shelter is designed to withstand.

#### **1.4 COORDINATION**

- A. Cast-in Anchorage: Coordinate installation of anchorages for shelters. Furnish sleeves, concrete inserts, anchor bolts, and items with integral anchors that are to be embedded in concrete bases. Include setting drawings, templates, and directions for installing anchorages. Deliver such items to Project site in time for installation.

### **PART 2 - PRODUCTS**

#### **2.1 PERFORMANCE REQUIREMENTS**

- A. Structural Performance: Shelters shall withstand the following loads and stresses within limits and under conditions indicated according to ASCE/SEI 7:
  - 1. Design Loads: As indicated on Drawings.

- B. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
  - 1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.

## 2.2 WOOD-FRAMED SHELTERS

- A. In conformance with the requirements of this section, provide pre-engineered pergola style kits available from commercial home improvement stores or garden centers. Shelters shall be fabricated from dimensioned lumber or heavy timber components ready for assembly on Project site.
- B. Building Style: Pergola style canopy structure open on all sides.
  - 1. Size: 72 inches by 144 inches.
- C. Structural Framework: Fabricated from dimensioned lumber or heavy timber members sized by manufacturer for indicated shelter size.
- D. Post Bases: Manufacturer's standard.
- E. Anchorage: Cast-in-place anchor bolts or postinstalled anchors, fabricated from stainless steel, with allowable load or strength design capacities calculated to be greater than or equal to the design load.
- F. Roof: Sloped joists at manufacturer's standard spacing with polycarbonate panels anchored to joists.
  - 1. Location: As indicated on Drawings.
- G. Materials:
  - 1. Dimension Lumber: Provide dimension lumber of grades indicated according to the ALSC National Grading Rule (NGR) provisions of the inspection agency indicated.
    - a. Where nominal sizes are indicated, provide actual sizes required by DOC PS 20 for moisture content specified. Where actual sizes are indicated, they are minimum dressed sizes for dry wood products.
    - b. Moisture Content: 15 percent for 2-inch nominal thickness or less; 19 percent for more than 2-inch nominal thickness.
    - c. Species and grade: Provide one of the following:
      - 1) No. 2 Mixed southern pine; SPIB.
      - 2) Heart B redwood; RIS.
      - 3) Clear Heart Western red cedar; NLGA, WCLIB, or WWPA.

2. Preservative Treatment: Pressure treat boards and dimension lumber with waterborne preservative according to AWWPA U1; Use Category UC3b for exterior construction not in contact with the ground, and Use Category UC4a for items in contact with the ground.
3. Fasteners: Provide fasteners of size and type indicated, acceptable to authorities having jurisdiction, and that comply with requirements specified in this article for material and manufacture. Provide screws, in sufficient length, to penetrate not less than 1-1/2 inches into wood substrate.
  - a. Use stainless steel unless otherwise indicated
4. Polycarbonate Glazing: Thermoformable, extruded monolithic sheets, UV resistant and with average impact strength of 12 to 16 ft-lb/in. of width when tested according to ASTM D 256, Test Method A (Izod).
  - a. Color: White, translucent.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, including concrete bases; accurate placement, pattern, and orientation of anchor bolts; critical dimensions; and other conditions affecting performance of the Work.
- B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.2 INSTALLATION**

- A. Install shelters according to manufacturer's written instructions.
- B. Set shelters plumb and aligned with full bearing on concrete bases.
- C. Fasten shelters securely to concrete base with anchorage indicated.

#### **3.3 ADJUSTING**

- A. After completing installation, inspect exposed finishes and repair damaged finishes.

**END OF SECTION**

**SECTION 111233**

**PARKING GATES**

**PART 1 - GENERAL**

1.1 SECTION INCLUDES

- A. High performance barrier gate operator and accessories.

1.2 RELATED SECTIONS

- A. DeIDOT Standard Section 602 – Concrete Structures.
- B. Division 26 - Requirements for electrical connections.

1.3 REFERENCES

- A. Underwriters' Laboratory (UL): Categories FDDR and FDDR7 - Door, Drapery, Gate, Louver, and Window Operators and Systems.

1.4 SUBMITTALS

- A. Submit under provisions DeIDOT stand specifications.
- B. Product Data: Equipment list, system description, electrical wiring diagrams for installation, and manufacturer's data sheets on each product to be used, including:
  - 1. Preparation instructions and recommendations.
  - 2. Storage and handling requirements and recommendations.
  - 3. Installation methods.
- C. Shop Drawings: Submit shop drawings showing layout, profiles, and product components, including anchorage, edge conditions, and accessories.
  - 1. Operation, installation, and maintenance manuals including wiring diagrams.
  - 2. Risers, layouts, and special wiring diagrams showing any changes to standard drawings.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store products in manufacturer's unopened packaging with labels intact until ready for installation.

- B. Schedule delivery of parking control equipment so that spaces are sufficiently complete that operators can be installed upon delivery.

#### 1.6 QUALITY ASSURANCE

- A. Perform installation by factory authorized contractor specifically trained in gate operation systems of the type found within this section.
- B. Provide documentation of maintenance and repair service availability for emergency conditions.
- C. Provide quarterly maintenance for one year following Substantial Completion of the Project.

#### 1.7 WARRANTY

- A. Manufacturer's standard warranty for two years or 2 million cycles.

### **PART 2 - PRODUCTS**

#### 2.1 MANUFACTURERS

- A. Acceptable Manufacturers:
  - 1. Magnetic Automation Corp.
  - 2. Guardian Traffic Systems
  - 3. Magnetic Autocontrol Corp.

#### 2.2 HIGH PERFORMANCE BARRIER GATE OPERATOR

- A. High Speed Barrier Gate Operator: Barrier open/close time 1.4-2.2 seconds, 100% duty cycle, boom length up to 14 feet.
- B. UL Classification:
  - 1. Conforms to UL Category FDDR - Door, Drapery, Gate, Louver and Window Operators and Systems Certified.
- C. Housing: Manufactured from 14 gauge steel onto steel base, then phosphate and powder coated for maximum protection against corrosion and superior durability.
- D. Drive Unit:
  - 1. 100% duty cycle spring-balanced AC torque ½ Horse Power motor, to run on 120 volts AC, providing 1.4-2.2sec open/close time in excess of 2 million cycles; maximum arm length 14 feet; left- or right-hand operation.

E. Controller:

1. Magnetic Lane Controller with built-in dual channel vehicle loop detectors, (5) potential free inputs and (2) 24V DC outputs, easy to program lane configurations and operation parameters via selector switch, push buttons and LCD display.

F. Additional Required Controls:

1. Low power consumption and high MCBF ( $> 2,000,000$  cycles).
2. Direct drive operation resulting in condensation/corrosion resistance, extremely low maintenance, ability to be stalled in any position without risk of damage, problem-free operation in cold climatic conditions and overall extended service life – no belts, pulleys or chains.
3. Modular construction with drive unit mounted to a heavy duty casting allowing easy access door to be mounted on any side of barrier.
4. Built-in position sensors (no limit switches) providing precise arm position status and a self-learning control unit to guarantee optimum braking and no boom arm bouncing, sagging or rotating out of position.
5. Easy to program controller for common lane configurations.

G. Gate Arm:

1. Arm: 14 foot octagonal aluminum arm.

H. Optional Equipment:

1. RS232/422/485 or TCP/IP communication.
2. Dual channel vehicle loop detector.
3. Additional foam protection inserted on the bottom of octagonal aluminum boom for extra safety.
4. Swing away flange.
5. Wood arm flange adaptor (wood boom supplied by customer).
6. Contact for release of barrier arm.
7. Additional I/O extension module.
8. Custom RAL color.

**PART 3 - EXECUTION**

3.1 EXAMINATION

- A. Do not begin installation until substrates have been properly prepared.
- B. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

3.2 PREPARATION

- A. Clean surfaces thoroughly prior to installation.
- B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3.3 INSTALLATION

- A. Install in accordance with manufacturer's instructions including the following:
  - 1. Mount directly to concrete pad, firmly secured, plumb and level.
  - 2. Wire in accordance with National Electric Code.
  - 3. Enclose all splices in easily accessible junction boxes or on terminal boards.
  - 4. Tag and identify all cable runs in all junction boxes.
- B. Test system and adjust to assure components and accessories are properly connected and in working order.

3.4 PROTECTION

- A. Protect installed products until completion of project.
- B. Touch-up, repair or replace damaged products before Substantial Completion.

3.5 MAINTENANCE

- A. Maintain at three-month intervals during specified maintenance period, primarily checking rubber end stops on direct drive unit

**END OF SECTION**

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## **SECTION 131200 – PRE-ENGINEERED, PRE-CAST CONCRETE OUTBUILDINGS**

### **PART 1 – GENERAL**

#### **1.1 SUMMARY**

- A. Section Includes:
  - 1. Pre-engineered, modular, pre-cast concrete toilet room buildings.
  - 2. Pre-engineered, modular, pre-cast concrete electrical service buildings.

#### **1.2 ACTION SUBMITTALS**

- A. Shop Drawings: For toilet room buildings showing configuration of building. Include plans, elevations, sections, and details indicating compliance with the requirements of the Contract Documents, including:
  - 1. Toilet room plumbing and electrical fixtures.
  - 2. Toilet room accessories.
- B. Shop Drawings: For electrical service buildings showing configuration of building. Include plans, elevations, sections, and details indicating compliance with the requirements of the Contract Documents, including coordination of all sleeves or embedded anchors for electrical equipment.

#### **1.3 INFORMATIONAL SUBMITTALS**

- A. Engineering calculations that are designed and sealed by a professional engineer, licensed to practice in the state of Delaware, shall be submitted for approval.
- B. Building installation manual.

#### **1.4 QUALITY ASSURANCE**

- A. ACI-318-02, “Building Code Requirements for Reinforced Concrete”, Concrete Reinforcing Institute, “Manual of Standard Practice”.
- B. ANSI/ASCE-7-02 “Building Code Requirement for Minimum Design Loads in Buildings and Other Structures”.
- C. IBC 2012
- D. Fabricator must be a certified producer/member of The Precast/Prestressed Concrete Institute (PCI), National Precast Concrete Association (NPCA) or equal.
- E. Building fabricator must have a minimum of 5 years experience manufacturing and setting transportable precast concrete buildings.

## **PART 2 – PRODUCTS**

### **2.1 MANUFACTURERS**

- A. Basis-of-Design Product: Subject to compliance with requirements, provide EASI-SET Industries, Midland, Virginia.
  - 1. Modular Toilet Rooms; “Sierra” Restroom building, or approved equal.

### **2.2 DESIGN REQUIREMENTS**

- A. Toilet Room Standard Models Dimensions: Provide a building of manufacturer’s standard dimensions that complies with the minimum and maximum dimensions indicated in Figure 1 at the end of Part 3.
- B. Electrical Service Building Dimensions: Provide a building with the minimum dimensions indicated in Figure 2 at the end of Part 3.
- C. Design Loads: As indicated on the Drawings, but not less than the following:
  - 1. Seismic load performance category ‘C’, Exposure Group III
  - 2. Standard Live Roof Load – 60 PSF
  - 3. Standard Floor Load – 250 PSF
  - 4. Standard Wind Loading – 130 MPH
- D. Gabled Roof: Roof panel shall slope approximately 24” from left to right or front to back in the short-sided direction. The roof shall extend a minimum of 6” beyond the wall panel all around have a turndown design which extends ½” below the top edge of the wall panels to further prevent water migration into the building along top of wall panels. Roof shall also have an integral architectural ribbed edge.
- E. Roof, floor, and wall panels must each be produced as single component monolithic panels. No roof, floor, or vertical wall joints will be allowed, except at corners. Wall panels shall be set on top of floor panel.
- F. Floor panel must have ½” step-down around the entire perimeter to prevent water migration into the building along the bottom of wall panels.
- G. Toilet Room Building plumbing shall be designed in accordance with the International Plumbing Code.
- H. Electrical systems shall be designed in accordance with the International Electric Code.
- I. All plumbing and electrical connections shall be made by licensed plumbers and electricians in the state where the building is installed.
- J. Accessibility - Prefabricated toilet buildings shall conform to the requirements of the “Uniform Federal Accessibility Standards” (UFAS) and the “Americans with

Disabilities Act Accessibility Guidelines” (ADAAG). Buildings shall have full 60-inch turning diameter in each interior and entry area. Comply with all additional requirements of the Delaware Architectural Accessibility Standards.

### 2.3 MATERIALS

- A. Concrete: Steel-reinforced, 5000 PSI minimum 28-day compressive strength, air-entrained (ASTM C260).
- B. Reinforcing Steel: ASTM A615, grade 60 unless otherwise specified.
- C. Post-tensioning Strand: 41K Polystrand CP50, .50, 270 KSI, 7-wire strand, enclosed within a greased plastic sheath, (ASTM A416). Roof and floor to be each post-tensioned by a single, continuous tendon. Said tendon shall form a substantially rectangular configuration having gently curving corners wherein the positioning of the cable member results in a pattern of one or more loops and a bisecting of the loop(s). The cable member starts from one corner of the concrete building panel, forms a gentle perimeter loop(s) returning to a point where the cable member entered the concrete building panel. The tendon then turns 90 degrees and follows the cable member(s) to a point midway along the “Y” axis of the concrete building panel and then turns 90 degrees along the “X” axis of the concrete building panel. This bisects the concrete building panel and crosses the opposite parallel portion of the cable member and exits from an adjacent side of the concrete building panel.
  - 1. If post-tensioning is not used in the roof panel, the following guidelines must be followed to ensure a watertight roof design.
    - a. The entire precast concrete roof panel surface must be cleaned and primed with a material that prepares the concrete surface for proper adherence to the coating material.
    - b. The entire precast concrete roof panel surface shall be sealed with a .045 EPDM continuous membrane cemented to the concrete with a compound designed for this purpose.
- D. Caulking: Joint between building and floor slab shall be caulked on the exterior and interior surface of the joints. Caulking shall be SIKAFLEX-1A elastic sealant or equal. Exterior caulk joint to be 3/8” x 3/8” square so that sides of joint are parallel for correct caulk adhesion. Back of joint to be taped with bond breaking tape to ensure adhesion of caulk to parallel sides of joint and not the back.
- E. Toilet Building Vents: Two screened aluminum vents to be cast in rear wall. Vents shall be SUNVENT #164FL or equal.
- F. Panel Connections: All panels shall be securely fastened together with 3/8” thick steel brackets. Steel is to be of structural quality, hot-rolled carbon complying with ASTM A283, Grade C and hot dipped galvanized after fabrication. All fasteners to be 1/2” diameter bolts complying with ASTM A307 for low-carbon steel bolts. Cast-in anchors used for panel connections to be Dayton-Superior #F-

63, or equal. All inserts for corner connections must be secured directly to form before casting panels. No floating-in of connection inserts shall be allowed.

## 2.4 TOILET ROOM BUILDING ACCESSORIES

- A. Doors and Frames: Shall comply with Steel Door Institute “Recommended Specifications for Standard Steel Doors and Frames” (SDI-100) and as herein specified. The buildings shall be equipped with double 3’-0” x 6’-8” x 1-3/4”, 18-gauge galvanized/insulated Dominion Imperial right hand reverse metal doors with 16-gauge galvanized frames. Doors and frames shall be bonderized and painted one coat of rust inhibitive primer and one finish coat of enamel paint; color shall be Yorktown Brown unless otherwise specified.
- B. Door Hardware:
1. Handle: Lindstrom stainless steel, 8-1/2” x 2” or equal.
  2. Hinges: PB-31/NRP/26D 4 1/2” x 4 1/2” (chrome-plated with non-removable hinge pins), 3 per door or equal.
  3. Lock Set: PDQ Industries KR116 – 32D (stainless steel finish) or equal.
  4. Surface Bolt, Upper: Cal-Royal 045901426D (satin chrome finish) or equal.
  5. Surface Bolt, Lower: Cal-Royal 045901426D (satin chrome finish) or equal.
  6. Astragal: A4441/68R or equal.
  7. Threshold: National Guard 897V60 raised interior, extruded aluminum threshold with neoprene seal or equal.
  8. Door Holder: Glynn-Johnson 904H US32D (stainless steel finish), overhead slide type surface mounted door holder or equal.
  9. Drip Cap: National Guard 15D72 or equal.
  10. Door Stop: Ives 445B26D (Inactive leaf only) or equal.
- C. Grab Bars: Stainless steel tubing, 1-1/2 inch outside diameter mounted 1-1/2 inches from wall, 18 gauge, type 304 Stainless steel concealed screw-mounting flanges, Bobrick series B-6806, 888-610-8889, or approved equal.
- D. Toilet Paper Dispenser: Bar-type toilet paper dispenser shall be constructed of stainless steel with satin finish or steel with glossy white enamel finish with neoprene sleeve, designed to hold three standard rolls of toilet paper. Holder shall not prevent the free turning of the paper rolls. The dispenser shall be manufactured by Romtec Inc., 18240 N. Bank Road, Roseburg, Oregon 97470, 541-496-3541 or approved equal.

## 2.5 ELECTRICAL SERVICE BUILDING ACCESSORIES

- A. Doors and Frames: Shall comply with Steel Door Institute “Recommended Specifications for Standard Steel Doors and Frames” (SDI-100) and as herein specified. The buildings shall be equipped with double 3’-0” x 6’-8” x 1-3/4”, 18-gauge galvanized/insulated Dominion Imperial right hand reverse metal doors

with 16-gauge galvanized frames. Doors and frames shall be bonderized and painted one coat of rust inhibitive primer and one finish coat of enamel paint; color shall be Yorktown Brown unless otherwise specified.

- B. Door Hardware:
  - 1. Handle: Lindstrom stainless steel, 8-1/2" x 2" or equal.
  - 2. Hinges: PB-31/NRP/26D 4 1/2" x 4 1/2" (chrome-plated with non-removable hinge pins), 3 per door or equal.
  - 3. Lock Set: PDQ Industries KR116 – 32D (stainless steel finish) or equal.
  - 4. Threshold: National Guard 897V60 raised interior, extruded aluminum threshold with neoprene seal or equal.
  - 5. Door Holder: Glynn-Johnson 904H US32D (stainless steel finish), overhead slide type surface mounted door holder or equal.
  - 6. Drip Cap: National Guard 15D72 or equal.
  - 7. Door Stop: Ives 445B26D (Inactive leaf only) or equal.
  
- C. HVAC: Provide manufacturer's standard wall-mount HVAC system designed to maintain interior temperatures between 40 and 78 degrees.

## 2.6 FINISHES

- A. Interior of Building: Smooth steel form finish on all interior panel surfaces.
  
- B. Exterior of Building:
  - 1. Architectural precast concrete: Finish must be imprinted in top face of panel while in form using an open grid impression tool. Grid size shall be nominal 8" x 16" CMU pattern and dimensions with finish to match ground face CMU. Joints between each block must be 3/8" wide x 3/8" deep. Back of joint shall be concave to simulate a hand-tooled joint. Each block face shall be coated with acrylic concrete stain applied per manufacturer's recommendation. Stain color to match one of the CMU colors identified in Section 042000 "Unit Masonry". Joints shall be kept substantially free of stain to maintain a gray concrete color.

## 2.7 TOILET ROOM PLUMBING

- A. Waste and vent piping: ABS or PVC plastic.
  
- B. Water piping: Copper tubing Type L, hard drawn. Provide a gate or ball valve at the inlet end of the water line. Size water lines to provide proper flushing action based on a nominal water pressure of 40 psi.
  
- C. Provide a main shut-off valve and drain in the service area.
  
- D. Toilet (water closet) and seat: Type 304 stainless steel, wall hung, with siphon jet action. Provide back spud for concealed flush valve connection.

- E. Flush valve: Concealed closet flush-o-meter constructed of rough brass with water saver flow of 1.6 gallons per flush. Furnish valve with integral vacuum breaker and wall mounted push button.
- F. Lavatory: Type 304 stainless steel, 20 inches wide x 18 inches front to back x 6 inches deep.
- G. Faucet: Self-closing water set with indexed push button.
- H. Hose bib: Provide single unit in the service area.
- I. Floor drains: Provide a floor drain in each room of the toilet building.

## 2.8 TOILET ROOM ELECTRICAL

- A. Provide a 100-amp breaker panel in the service area.
- B. Wire: Copper.
- C. Light fixtures:
  - 1. Service area: 2 each, 4-foot ceiling mounted fluorescent, switch and motion detector controlled.
  - 2. Toilet rooms: Motion detector that activates fluorescent fixtures in service area.
  - 3. Outdoor: 35-watt high-pressure sodium, cast aluminum case, rated for outdoor use, photocell activated.
  - 4. Hand dryer: Air compression type with remote motor unit. Push button switch located in cast nozzle housing with flexible hose connecting blower motor, housing and nozzle. Power input 120VAC, 7A (non-heated air).

## PART 3 – EXECUTION

### 3.1 EXAMINATION

- A. Examine site for building placement with Manufacturer present for compliance with requirements and other conditions affecting installation:
  - 1. Verify that bedding and backfill are prepared in accordance with manufacturer's requirements.
  - 2. Verify that utilities are placed and properly sized for connection to building.

### 3.2 PREPARATION

- A. Contractor shall coordinate with the manufacturer of the precast concrete building to accommodate installation at the time of delivery. The Contractor shall be responsible to obtain installation instructions from the manufacturer and perform the excavation, backfill, and site grading in accordance with those instructions.

The excavation shall be over excavated two feet (horizontal measurement) on each side of the slab to allow for compaction and minor adjustments in orientation.

- B. Building shall bear fully on a crushed stone base that is at least two feet larger than the length and width of building.
- C. Stone shall be a minimum of 4" thick or down to firm subgrade. The vertical soil capacity under stone shall be compacted to have minimum bearing of 1,500 pounds per square foot. Stone shall be 3/8" or smaller and must be screeded level within 1/4" in both directions. Stone shall be placed within a perimeter form with flat and level top edge for screeding. Forming material shall remain around stone until after the building is set.
- D. The crushed stone base shall be kept within the confines of the soil or perimeter form. Do not allow the stone base to become unconfined so that it may wash, erode, or otherwise be undermined.
- E. Provide positive drainage for the fill, concrete pad, or slab as required.

### 3.2 INSTALLATION

- A. Building shall be installed according to the manufacturer's installation instructions.
- B. Bedding:
  - 1. The Contractor shall place a leveling course prior to placement of the building.
  - 2. Grade leveling course so there will be no high spots in the middle.
  - 3. Minimum compacted leveling course for building slab shall be 6 inches.
- C. Plumbing and Electrical Connections: Make connections to water and sewer lines and electrical service in accordance with manufacturer's instructions.
- D. Finish grading: All surfaces and slopes shall be shaped to blend with the original ground line, mounded over or smoothed off, and raked, and left in a uniform and neat condition. Stockpiled topsoil shall be smoothly distributed over disturbed areas and hand raked to blend with ground line. Final grade shall be flush with top of front slab to provide accessibility. Surface drainage shall be diverted so that it will not enter into the area.

### 3.3 PROTECTION AND CLEANING

- A. Building shall be not be used by contractor's personnel or sub-contractors after installation and connection.
- B. Clean interiors and exteriors of building after installation and connections are completed. Lock building and deliver keys to the Owner after final cleaning.

Figure 1

Figure 2

## **SECTION 211100 - FACILITY FIRE-SUPPRESSION WATER-SERVICE PIPING**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

- A. Section includes fire-suppression water-service piping and related components outside the building and service entrance piping through floor into the building and the following:
  - 1. Pipes, fittings, and specialties.
  - 2. Fire-suppression specialty valves.
  - 3. Concrete vaults.
  - 4. Protective enclosures.
  - 5. Alarm devices.
- B. Utility-furnished products include water meters that are furnished to the site, ready for installation.

#### **1.2 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
- B. Shop Drawings:
  - 1. Detail precast concrete vault assemblies and indicate dimensions, method of field assembly, and components.
  - 2. Include diagrams for power, signal, and control wiring.

#### **1.3 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: For piping and specialties including relation to other services in same area, drawn to scale. Show piping and specialty sizes and valves, meter and specialty locations, and elevations.
- B. Field quality-control reports.

#### **1.4 QUALITY ASSURANCE**

- A. Regulatory Requirements:
  - 1. Comply with requirements of utility company supplying the water. Include tapping of water mains and backflow prevention.
  - 2. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.

- B. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with FM Global's "Approval Guide" or UL's "Fire Protection Equipment Directory" for fire-service-main products.
- E. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-suppression water-service piping.

## **PART 2 - PRODUCTS**

### **2.1 COPPER TUBE AND FITTINGS**

- A. Soft Copper Tube: **ASTM B 88, Type K**, water tube, annealed temper.
- B. Hard Copper Tube: **ASTM B 88, Type K**, water tube, drawn temper.
- C. Copper, Solder-Joint Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint pressure type. Furnish only wrought-copper fittings if indicated.
- D. Copper, Pressure-Seal Fittings:
  - 1. **Manufacturers**: Subject to compliance with requirements, provide products by one of the following:
    - a. **Viega; Plumbing & Heating Systems**.
    - b. Approved Equal
  - 2. Standard: UL 213.
  - 3. **NPS 2** and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
  - 4. **NPS 2-1/2 to NPS 4**: Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.
- E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end. Furnish Class 300 flanges if required to match piping.
- F. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

## 2.2 DUCTILE-IRON PIPE AND FITTINGS

- A. Grooved-Joint, Ductile-Iron Pipe: AWWA C151, with cut, rounded-grooved ends.
- B. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end.
- C. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end.
- D. Grooved-End, Ductile-Iron Pipe Appurtenances:
  - 1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
    - a. Anvil International, Inc.
    - b. Corcoran Piping Systems Inc.
    - c. Shurjoint Piping Products.
    - d. Star Pipe Products.
    - e. Tyco Fire & Building Products LP.
    - f. Venus Fire Protection Ltd.
    - g. Victaulic Company.
    - h. Viking Corporation.
  - 2. Grooved-End, Ductile-Iron Fittings: ASTM A 47/A 47M, malleable-iron castings or ASTM A 536, ductile-iron castings with dimensions matching pipe.
  - 3. Grooved-End, Ductile-Iron-Piping Couplings: AWWA C606, for ductile-iron-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.
- E. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
  - 1. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
- F. Push-on-Joint, Ductile-Iron Fittings: AWWA C153, ductile-iron compact pattern.
  - 1. Gaskets: AWWA C111, rubber.
- G. Flanges: ASME B16.1, Class 125, cast iron.

## 2.3 SPECIAL PIPE FITTINGS

- A. Ductile-Iron Flexible Expansion Joints:

1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
  - a. **EBA A Iron, Inc.**
  - b. **ROMAC Industries Inc.**
  - c. **Star Pipe Products.**
2. **Description:** Compound, ductile-iron fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include two gasketed ball-joint sections and one or more gasketed sleeve sections. Assemble components for offset and expansion indicated. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
3. **Pressure Rating:** 250 psig minimum.

B. Ductile-Iron Deflection Fittings:

1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
  - a. **EBA A Iron, Inc.**
  - b. **Approved equal.**
2. **Description:** Compound, ductile-iron coupling fitting with sleeve and one or two flexing sections for up to 15-degree deflection, gaskets, and restrained-joint ends complying with AWWA C110 or AWWA C153. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
3. **Pressure Rating:** 250 psig minimum.

2.4 JOINING MATERIALS

- A. **Gaskets for Ferrous Piping and Copper-Alloy Tubing:** ASME B16.21, asbestos free.
- B. **Brazing Filler Metals:** AWS A5.8/A5.8M, BCuP Series.

2.5 PIPING SPECIALTIES

- A. **Transition Fittings:** Manufactured fitting or coupling same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.
- B. **Tubular-Sleeve Pipe Couplings:**
  1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
    - a. **Cascade Waterworks Manufacturing.**
    - b. **Ford Meter Box Company, Inc. (The); Pipe Products Division.**

- c. **Smith-Blair, Inc.; a Sensus company.**
  - d. **Viking Johnson.**
2. Description: Metal, bolted, sleeve-type, reducing or transition coupling, with center sleeve, gaskets, end rings, and bolt fasteners, and with ends of same sizes as piping to be joined.
  3. Standard: AWWA C219.
  4. Center-Sleeve Material: Manufacturer's standard.
  5. Gasket Material: Natural or synthetic rubber.
  6. Pressure Rating: **150 psig** minimum.
  7. Metal Component Finish: Corrosion-resistant coating or material.

## 2.6 CORPORATION VALVES

- A. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
  1. **Ford Meter Box Company, Inc. (The); Pipe Products Division.**
  2. **Jones, James Company.**
  3. **McDonald, A. Y. Mfg. Co.**
  4. **Mueller Co.; Water Products Division.**
- B. Corporation Valves: Comply with AWWA C800. Include saddle and valve compatible with tapping machine.
  1. Service Saddle: Copper alloy with seal and AWWA C800, threaded outlet for corporation valve.
  2. Corporation Valve: Bronze body and ground-key plug, with AWWA C800, threaded inlet and outlet matching service piping material.
  3. Manifold: Copper fitting with two to four inlets as required, with ends matching corporation valves and outlet matching service piping material.
- C. Meter Valves: Comply with AWWA C800 for high-pressure, service-line valves. Include angle- or straight-through-pattern bronze body, ground-key plug or ball, and wide tee head, with inlet and outlet matching service piping material.

## 2.7 CURB VALVES

- A. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
  1. **Ford Meter Box Company, Inc. (The); Pipe Products Division.**
  2. **Jones, James Company.**
  3. **McDonald, A. Y. Mfg. Co.**
  4. **Mueller Co.; Water Products Division.**

- B. Curb Valves: Comply with AWWA C800 for high-pressure, service-line valves. Valve has bronze body, ground-key plug or ball, wide tee head, and inlet and outlet matching service piping material.
- C. Service Boxes for Curb Valves: Similar to AWWA M44 requirements for cast-iron valve boxes. Include cast-iron telescoping top section of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over curb valve and with a barrel approximately 3 inches in diameter.
  - 1. Shutoff Rods: Steel; with tee-handle with one pointed end, stem of length to operate deepest buried valve, and slotted end matching curb valve.
- D. Meter Valves: Comply with AWWA C800 for high-pressure, service-line valves. Include angle- or straight-through-pattern bronze body, ground-key plug or ball, and wide tee head, with inlet and outlet matching service piping material.

## 2.8 DETECTOR CHECK VALVES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Ames Fire & Waterworks; a division of Watts Water Technologies, Inc.
  - 2. Flomatic Corporation.
  - 3. Mueller Co.; Hersey Meters Division.
  - 4. Watts Water Technologies, Inc.
- B. Description: Galvanized cast-iron body, bolted cover with air-bleed device for access to internal parts, and flanged ends. Include one-piece bronze disc with bronze bushings, pivot, and replaceable seat. Include threaded bypass taps in inlet and outlet for bypass meter connection. Set valve to allow minimal water flow through bypass meter when major water flow is required.
- C. Standards: UL 312 and FM Global's "Approval Guide."
- D. Pressure Rating: 175 psig.
- E. Water Meter: AWWA C700, disc type, at least one-fourth size of detector check valve. Include meter, bypass piping, gate valves, check valve, and connections to detector check valve.

## 2.9 WATER METERS

- A. Water meters are furnished by utility company.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AMCO Water Metering Systems.
2. Hays Fluid Controls.
3. Mueller Co.; Hersey Meters Division.
4. Sensus Metering Systems.

C. Displacement-Type Water Meters:

1. Description: With bronze main case.
2. Standard: AWWA C700.
3. Registration: Flow in gallons.

D. Turbine-Type Water Meters:

1. Standard: AWWA C701.
2. Registration: Flow in gallons.

E. Compound-Type Water Meters:

1. Standard: AWWA C702.
2. Registration: Flow in gallons.

F. Remote Registration System:

1. Description: Utility company's standard; direct-reading type. Include meter modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly.
2. Standard: AWWA C706.
3. Registration: Flow in gallons.

G. Remote Registration System:

1. Description: Utility company's standard; encoder type. Include meter modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly.
2. Standard: AWWA C707.
3. Registration: Flow in gallons.
4. Data-Acquisition Units: Comply with utility company's requirements for type and quantity.
5. Visible Display Units: Comply with utility company's requirements for type and quantity.

## 2.10 WATER METER BOXES

A. Description: Cast-iron body and cover for disc-type water meter, with lettering "WATER METER" on cover; and with slotted, open-bottom base section of length to fit over service piping.

1. Option: Base section may be cast-iron, PVC, clay, or other pipe.

- B. Description: Cast-iron body and double cover for disc-type water meter, with lettering "WATER METER" on top cover; and with separate inner cover; air space between covers; and slotted, open-bottom base section of length to fit over service piping.
- C. Description: Polymer-concrete body and cover for disc-type water meter, with lettering "WATER" on cover; and with slotted, open-bottom base section of length to fit over service piping. Include vertical and lateral design loadings of **15,000 lb minimum over 10 by 10 inches** square.

## 2.11 CONCRETE VAULTS

- A. Description: Precast, reinforced-concrete vault, designed for A-16 load designation according to ASTM C 857, and made according to ASTM C 858.
- B. Ladder: ASTM A 36/A 36M, steel ladder; or PE-encased steel steps.
- C. Manhole: ASTM A 48/A 48M, Class No. 35A minimum tensile strength, gray-iron traffic frame and cover.
  - 1. Dimension: **24-inch** minimum diameter unless otherwise indicated.
- D. Manhole: ASTM A 536, Grade 60-40-18, ductile-iron traffic frame and cover.
  - 1. Dimension: **24-inch** minimum diameter unless otherwise indicated.
- E. Drain: ASME A112.6.3, cast-iron floor drain with outlet of size indicated. Include body anchor flange, light-duty cast-iron grate, bottom outlet, and integral or field-installed bronze ball or clapper-type backwater valve.

## PART 3 - EXECUTION

### 3.1 EARTHWORK

- A. Comply with excavating, trenching, and backfilling requirements in Section 312000 "Earth Moving."

### 3.2 PIPING INSTALLATION

- A. Water-Main Connection: Arrange with water utility company for tap of size and in location indicated in water main.
- B. Water-Main Connection: Tap water main according to requirements of water utility company and of size and in location indicated.
- C. Make connections larger than **NPS 2** with tapping machine according to the following:

1. Install tapping sleeve and tapping valve according to MSS SP-60.
  2. Install tapping sleeve on pipe to be tapped. Position flanged outlet for gate valve.
  3. Use tapping machine compatible with valve and tapping sleeve; cut hole in main. Remove tapping machine and connect water-service piping.
  4. Install gate valve onto tapping sleeve. Comply with MSS SP-60. Install valve with stem pointing up and with valve box.
- D. Make connections **NPS 2** and smaller with drilling machine according to the following:
1. Install service-saddle assemblies and corporation valves in size, quantity, and arrangement required by utility company's standards.
  2. Install service-saddle assemblies on water-service pipe to be tapped. Position outlets for corporation valves.
  3. Use drilling machine compatible with service-saddle assemblies and corporation valves. Drill hole in main. Remove drilling machine and connect water-service piping.
  4. Install corporation valves into service-saddle assemblies.
  5. Install manifold for multiple taps in water main.
  6. Install curb valve in water-service piping with head pointing up and with service box.
- E. Comply with NFPA 24 for fire-service-main piping materials and installation.
- F. Install copper tube and fittings according to CDA's "Copper Tube Handbook."
- G. Install ductile-iron, water-service piping according to AWWA C600 and AWWA M41.
1. Install encasement for piping according to ASTM A 674 or AWWA C105.
- H. Bury piping with depth of cover over top at least **30 inches**, with top at least **12 inches** below level of maximum frost penetration, and according to the following:
1. Under Driveways: With at least **36 inches** of cover over top.
  2. In Loose Gravelly Soil and Rock: With at least **12 inches** of additional cover.
- I. Install piping by tunneling or jacking, or combination of both, under streets and other obstructions that cannot be disturbed.
- J. Install underground piping with restrained joints at horizontal and vertical changes in direction. Use restrained-joint piping, thrust blocks, anchors, tie-rods and clamps, and other supports.

### 3.3 JOINT CONSTRUCTION

- A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure rating same as or higher than systems pressure rating for aboveground applications unless otherwise indicated.
- B. Install unions adjacent to each valve in tubing **NPS 2** and smaller.
- C. Install flanges, flange adaptors, or couplings for grooved-end piping on valves, apparatus, and equipment having **NPS 2-1/2** and larger end connections.
- D. Ream ends of tubes and remove burrs.
- E. Remove scale, slag, dirt, and debris from outside and inside of pipes, tubes, and fittings before assembly.
- F. Copper-Tubing, Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Braze Joints" Chapter.
- G. Copper-Tubing, Pressure-Sealed Joints: Use proprietary crimping tool and procedure recommended by copper, pressure-seal-fitting manufacturer.
- H. Ductile-Iron Piping, Gasketed Joints for Fire-Service-Main Piping: UL 194.
- I. Ductile-Iron Piping, Grooved Joints: Cut-groove pipe. Assemble joints with grooved-end, ductile-iron-piping couplings, gaskets, lubricant, and bolts.
- J. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with bolts according to ASME B31.9.
- K. Dissimilar Materials Piping Joints: Use adapters compatible with both piping materials, with OD, and with system working pressure.
- L. Do not use flanges or unions for underground piping.

### 3.4 ANCHORAGE INSTALLATION

- A. Anchorage, General: Install water-distribution piping with restrained joints. Anchorages and restrained-joint types that may be used include the following:
  - 1. Concrete thrust blocks.
  - 2. Locking mechanical joints.
  - 3. Set-screw mechanical retainer glands.
  - 4. Bolted flanged joints.
  - 5. Heat-fused joints.
  - 6. Pipe clamps and tie rods.

- B. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches in fire-suppression water-service piping according to NFPA 24 and the following:
  - 1. Gasketed-Joint, Ductile-Iron, Water-Service Piping: According to AWWA C600.
  - 2. Gasketed-Joint, PVC Water-Service Piping: According to AWWA M23.
- C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

### 3.5 VALVE INSTALLATION

- A. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.
- B. AWWA Valves Other Than Gate Valves: Comply with AWWA C600 and AWWA M44.
- C. UL-Listed or FM Global-Approved Gate Valves: Comply with NFPA 24. Install each underground valve and valves in vaults with stem pointing up and with vertical cast-iron indicator post.
- D. UL-Listed or FM Global-Approved Valves Other Than Gate Valves: Comply with NFPA 24.
- E. MSS Valves: Install as component of connected piping system.
- F. Corporation Valves and Curb Valves: Install each underground curb valve with head pointed up and with service box.
- G. Support valves and piping, not direct buried, on concrete piers. Comply with requirements for concrete piers in Section 033000 "Cast-in-Place Concrete."

### 3.6 DETECTOR CHECK VALVE INSTALLATION

- A. Install in vault or aboveground.
- B. Install for proper direction of flow. Install bypass with water meter, gate valves on each side of meter, and check valve downstream from meter.
- C. Support detector check valves and piping on concrete piers. Comply with requirements for concrete piers in Section 033000 "Cast-in-Place Concrete."

### 3.7 WATER METER INSTALLATION

- A. Install water meters, piping, and specialties according to utility company's written instructions.

- B. Water Meters: Install displacement-type water meters **NPS 2** and smaller in meter boxes with shutoff valves on water meter inlets. Include valves on water meter outlets, and include valved bypass around meters unless prohibited by authorities having jurisdiction.
- C. Water Meters: Install compound-type water meters **NPS 3** and larger in meter vaults. Include shutoff valves on water meter inlets and outlets, and include valved bypass around meters. Support meters, valves, and piping on brick or concrete piers.
- D. Support water meters and piping **NPS 3** and larger on concrete piers. Comply with requirements for concrete piers in Section 033000 "Cast-in-Place Concrete."

### 3.8 ROUGHING-IN FOR WATER METERS

- A. Rough-in piping and specialties for water meter installation according to utility company's written instructions.

### 3.9 WATER METER BOX INSTALLATION

- A. Install water meter boxes in paved areas flush with surface.
- B. Install water meter boxes in grass or earth areas with top **2 inches** above surface.

### 3.10 CONCRETE VAULT INSTALLATION

- A. Install precast concrete vaults according to ASTM C 891.

### 3.11 ALARM DEVICE INSTALLATION

- A. General: Comply with NFPA 24 for devices and methods of valve supervision. Underground valves with valve box do not require supervision.
- B. Locking and Sealing: Secure unsupervised valves as follows:
  - 1. Valves: Install chain and padlock on open OS&Y gate valve.
  - 2. Post Indicators: Install padlock on wrench on indicator post.

### 3.12 CONNECTIONS

- A. Connect fire-suppression water-service piping to existing water main. Use tapping sleeve and tapping valve.
- B. Connect fire-suppression water-service piping to interior fire-suppression piping.

### 3.13 FIELD QUALITY CONTROL

- A. Use test procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described below.

- B. Piping Tests: Conduct piping tests before joints are covered and after concrete thrust blocks have hardened sufficiently. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.
- C. Hydrostatic Tests: Test at not less than one-and-one-half times the working pressure for two hours.
  - 1. Increase pressure in **50-psig** increments and inspect each joint between increments. Hold at test pressure for one hour; decrease to **zero psig**. Slowly increase again to test pressure and hold for one more hour. Maximum allowable leakage is **2 quarts** per hour per 100 joints. Remake leaking joints with new materials and repeat test until leakage is within allowed limits.
- D. Prepare test and inspection reports.

### 3.14 IDENTIFICATION

- A. Install continuous underground detectable warning tape during backfilling of trench for underground fire-suppression water-service piping. Locate below finished grade, directly over piping.
- B. Permanently attach equipment nameplate or marker indicating plastic fire-suppression water-service piping or fire-suppression water-service piping with electrically insulated fittings, on main electrical meter panel.

### 3.15 PIPING SCHEDULE

- A. Underground fire-suppression water-service piping **NPS 2** and smaller shall be the following:
  - 1. **NPS 2** PE, Class 150, fire-service pipe; molded PE fittings; and heat-fusion joints.
- B. Underground fire-suppression water-service piping **NPS 3** shall be one of the following:
  - 1. Grooved-end, ductile-iron pipe; grooved-end, ductile-iron pipe appurtenances; and grooved joints.
  - 2. Mechanical-joint, ductile-iron pipe; mechanical-joint, ductile- or gray-iron, standard-pattern fittings; glands, gaskets, and bolts; and gasketed joints.
  - 3. Push-on-joint, ductile-iron pipe; push-on-joint, ductile-iron compact-pattern fittings; and gasketed joints.
  - 4. PE, Class 150, fire-service pipe; molded PE fittings; and heat-fusion joints.

- C. Underground fire-suppression water-service piping **NPS 4** shall be one of the following:
  - 1. Grooved-end, ductile-iron pipe; grooved-end, ductile-iron pipe appurtenances; and grooved joints.
  - 2. Mechanical-joint, ductile-iron pipe; mechanical-joint, ductile- or gray-iron, standard-pattern fittings; glands, gaskets, and bolts; and gasketed joints.
  - 3. Push-on-joint, ductile-iron pipe; push-on-joint, ductile-iron compact-pattern fittings; and gasketed joints.
  
- D. Underground fire-suppression water-service piping NPS 6 to NPS 12 shall be one of the following:
  - 1. Grooved-end, ductile-iron pipe; grooved-end, ductile-iron pipe appurtenances; and grooved joints.
  - 2. Mechanical-joint, ductile-iron pipe; mechanical-joint, ductile- or gray-iron, standard-pattern fittings; glands, gaskets, and bolts; and gasketed joints.
  - 3. Push-on-joint, ductile-iron pipe; push-on-joint, ductile-iron compact-pattern fittings; and gasketed joints.
  
- E. Vault fire-suppression water-service piping NPS 2 and smaller shall be hard copper tube, ASTM B 88, Type K; wrought- or cast-copper-alloy, solder-joint fittings; and brazed joints.
  
- F. Vault fire-suppression water-service piping NPS 3 and NPS 4 shall be one of the following:
  - 1. Grooved-end, ductile-iron pipe; grooved-end, ductile-iron pipe appurtenances; and grooved joints.
  
- G. Vault fire-suppression water-service piping **NPS 5 to NPS 12** shall be grooved-end, ductile-iron pipe; grooved-end, ductile-iron pipe appurtenances; and grooved joints.
  
- H. Underslab fire-suppression water-service piping **NPS 2** and smaller shall be soft copper tube, **ASTM B 88, Type K**; wrought-copper, solder-joint fittings; and brazed joints.
  
- I. Underslab fire-suppression water-service piping **NPS 3 and NPS 4** shall be one of the following:
  - 1. Grooved-end, ductile-iron pipe; grooved-end, ductile-iron pipe appurtenances; and grooved joints.
  - 2. Mechanical-joint, ductile-iron pipe; mechanical-joint, ductile- or gray-iron, standard-pattern fittings; glands, gaskets, and bolts; and restrained, gasketed joints.

3. Push-on-joint, ductile-iron pipe; push-on-joint, ductile-iron compact-pattern fittings; and restrained, gasketed joints.
- J. Underslab fire-suppression water-service piping **NPS 6 to NPS 12** shall be one of the following:
1. Grooved-end, ductile-iron pipe; grooved-end, ductile-iron pipe appurtenances; and grooved joints.
  2. Mechanical-joint, ductile-iron pipe; mechanical-joint, ductile- or gray-iron, standard-pattern fittings; glands, gaskets, and bolts; and restrained, gasketed joints.
  3. Push-on-joint, ductile-iron pipe; push-on-joint, ductile-iron compact-pattern fittings; and restrained, gasketed joints.

### 3.16 VALVE SCHEDULE

- A. Underground fire-suppression water-service shutoff valves **NPS 2** and smaller shall be corporation valves or curb valves with ends compatible with piping.
- B. Meter box fire-suppression water-service shutoff valves **NPS 2** and smaller shall be meter valves.
- C. Vault fire-suppression water-service shutoff valves **NPS 2** and smaller shall be UL-listed or FM Global-approved, OS&Y, bronze, gate valves.
- D. Underground fire-suppression water-service shutoff valves **NPS 3** and larger shall be one of the following:
1. **200-psig**, AWWA, iron, nonrising-stem, resilient-seated gate valves.
  2. **250-psig**, AWWA, iron, nonrising-stem, resilient-seated gate valves.
  3. **175-psig**, UL-listed or FM Global-approved, iron, nonrising-stem gate valves.
- E. Indicator-post underground fire-suppression water-service valves **NPS 3** and larger shall be **175-psig**, UL-listed or FM Global-approved, iron, nonrising-stem gate valves with indicator-post flange.
- F. Standard-pressure, aboveground and vault fire-suppression water-service shutoff valves **NPS 3** and larger shall be one of the following:
1. **200-psig**, AWWA, iron, OS&Y, resilient-seated gate valves.
  2. **250-psig**, AWWA, iron, OS&Y, resilient-seated gate valves.
  3. **175-psig**, UL-listed or FM Global-approved, iron, OS&Y gate valves.
  4. AWWA or UL-listed or FM Global-approved butterfly valves.
- G. Fire-suppression water-service check valves **NPS 3** and larger shall be one of the following:

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1. AWWA or UL-listed or FM Global-approved check valves.
2. UL-listed or FM Global-approved detector check valves.

**END OF SECTION**

**SECTION 221113 - FACILITY WATER DISTRIBUTION PIPING**

**PART 1 - GENERAL**

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions, Special Provisions, the Tidewater Utilities, Inc. “Water Main Construction Specifications”, and Sussex County Government County Code “Chapter 110. Water and Sewers” as modified and added to apply to this section. In case of conflict between the standard specifications and the specifications herein, and other contract documents, the more stringent requirement shall govern only to the extent of such a conflict.

1.2 RELATED SECTIONS

- A. DeDOT Standard Specification Section 208 - Excavation and Backfilling for Pipe Trenches

1.3 SUMMARY

- A. This Section includes water-distribution piping and related components outside the building for water service.

1.4 ACTION SUBMITTALS

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

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.7 QUALITY ASSURANCE

- A. Regulatory Requirements
  - 1. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
  - 2. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with ASTM F 645 for selection, design, and installation of thermoplastic water piping.

- C. NSF Compliance.
  - 1. Comply with NSF 14 for plastic potable-water-service piping. Include marking "NSF-pw" on piping.
  - 2. Comply with NSF 61 for materials for water-service piping and specialties for domestic water.

## **PART 2 - PRODUCTS**

### **2.1 PIPE AND FITTINGS**

- A. Soft Copper Tube: Per Tidewater Utilities Inc. Standards.
- B. Hard Copper Tube: Per Tidewater Utilities Inc. Standards.
- C. Mechanical-Joint, Ductile-Iron Pipe: Per Tidewater Utilities Inc. Standards.
- D. Push-on-Joint, Ductile-Iron Pipe: Per Tidewater Utilities Inc. Standards.
- E. Grooved-Joint, Ductile-Iron Pipe: Per Tidewater Utilities Inc. Standards.
- F. PVC, AWWA Pipe: Per Tidewater Utilities Inc. Standards.
- G. Push-on-Joint, Ductile-Iron Fittings: Per Tidewater Utilities Inc. Standards.
  - 1. Mechanical-Joint, Ductile-Iron Fittings: Per Tidewater Utilities Inc. Standards.

### **2.2 JOINING MATERIALS**

- A. Refer to Section Tidewater Utilities Inc. Standards for commonly used joining materials.
- B. Brazing Filler Metals: AWS A5.8, BCuP Series and Tidewater Utilities Inc. Standards.
- C. Bonding Adhesive for Fiberglass Piping: As recommended by fiberglass piping manufacturer -and Tidewater Utilities Inc. Standards and Tidewater Utilities Inc. Standards.
- D. Plastic Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated and Tidewater Utilities Inc. Standards.

### **2.3 PIPING SPECIALITIES**

- A. Transition Fittings: Manufactured fitting or coupling same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.
- B. Tubular-Sleeve Pipe Couplings.

1. Description: Metal, bolted, sleeve-type, reducing or transition coupling, with center sleeve, gaskets, end rings, and bolt fasteners and with ends of same sizes as piping to be joined.
  - a. Standard: AWWA C219.

### **PART 3 - EXECUTION**

#### **3.1 EARTHWORK**

- A. Refer to DeIDOT Standard Specification Section 208 "Excavation and Backfilling for Pipe Trenches" for excavating, trenching, and backfilling.

#### **3.2 PIPING APPLICATIONS**

- A. General: Use pipe, fittings, and joining methods for piping systems according to the following applications.
- B. Transition couplings and special fittings with pressure ratings at least equal to piping pressure rating may be used, unless otherwise indicated.
- C. Do not use flanges or unions for underground piping.
- D. Flanges, unions, and special fittings may be used, instead of joints indicated, on aboveground piping and piping in vaults.
- E. Underground water-service piping shall be any of the following and must conform with Tidewater Utilities Inc. Standards:
  1. Soft copper tube, ASTM B 88, Type K or ASTM B 88, Type L; wrought-copper, solder-joint fittings; and brazed joints.
  2. Ductile-iron, mechanical-joint pipe; ductile-iron, mechanical-joint fittings; and mechanical] joints.
  3. NPS 4 and NPS 6: NPS 6 PVC, AWWA Class 150 pipe; PVC, AWWA Class 150 molded fittings; and gasketed joints.

#### **3.3 PIPING INSTALLATION**

- A. Install ductile-iron, water-service piping according to AWWA C600, AWWA M41 and Tidewater Utilities Inc. Standards.
- B. Install PE pipe according to ASTM D 2774, ASTM F 645 and Tidewater Utilities Inc. Standards.
- C. Install PVC, AWWA pipe according to ASTM F 645 AWWA M23and Tidewater Utilities Inc. Standards.

- D. Bury piping with depth of cover over top as required by Tidewater Utilities Inc. Standards.
- E. Extend water-service piping and connect to water-supply source and building-water-piping Systems at outside face of building wall in locations and pipe sizes indicated.
  - 1. Terminate water-service piping at building wall until building-water-piping systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building-water-piping systems when those systems are installed.
- F. Install underground piping with restrained joints at horizontal and vertical changes in direction. Use restrained-joint piping, thrust blocks, anchors, tie-rods and clamps, and other supports.

### 3.4 JOINT CONSTRUCTION

- A. Make pipe joints according to the following and Tidewater Utilities Inc. Standards:
  - 1. Ductile-Iron Piping, Gasketed Joints for Water-Service Piping: AWWA C600 and AWWA M41.
  - 2. Ductile-Iron Piping, Gasketed Joints for Fire-Service-Main Piping: UL 194.
  - 3. Ductile-Iron Piping, Grooved Joints: Cut-groove pipe. Assemble joints with grooved-end, ductile-iron-piping couplings, gaskets, lubricant, and bolts according to coupling manufacturer's written instructions.
  - 4. PE Piping Insert-Fitting Joints: Use plastic insert fittings and fasteners according to fitting manufacturer's written instructions.
  - 5. PVC Piping Gasketed Joints: Use joining materials according to AWWA C900. Construct joints with elastomeric seals and lubricant according to ASTM D 2774 or ASTM D 3139 and pipe manufacturer's written instructions.
  - 6. Dissimilar Materials Piping Joints: Use adapters compatible with both piping materials, with OD, and with system working pressure.

### 3.5 ANCHORAGE INSTALLATION

- A. Anchorage, General: Install water-distribution piping with restrained joints. Anchorages and restrained-joint types that may be used include the following and Tidewater Utilities Inc. Standards:
  - 1. Concrete thrust blocks.
  - 2. Locking mechanical joints.
  - 3. Set screw mechanical retainer glands.

4. Bolted flanged joints.
  5. Heat fused joints.
  6. Pipe clamps and tie rods.
- B. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches. Include anchorages for the following piping systems and Tidewater Utilities Inc. Standards:
1. Gasketed-Joint, Ductile-Iron, Water-Service Piping: According to AWWA C600.
  2. Gasketed-Joint, PVC Water-Service Piping: According to AWWA M23.
  3. Fire-Service-Main Piping: According to NFPA 24.
- C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

### 3.6 CONNECTIONS

- A. Connect water-distribution piping to interior domestic water piping.

### 3.7 FIELD QUALITY CONTROL

- A. Piping Tests: Conduct piping tests before joints are covered and after concrete thrust blocks have hardened sufficiently. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water comply with Tidewater Utilities Inc. Standards.
- B. Hydrostatic Tests: Test at not less than one-and-one-half times working pressure for two hours or per Tidewater Utilities Inc. Standards, whichever is more stringent.
1. Increase pressure in 50-psig increments and inspect each joint between increments. Hold at test pressure for 1 hour; decrease to 0 psig. Slowly increase again to test pressure and hold for 1 more hour. Maximum allowable leakage is 2 quarts per hour per 100 joints. Remake leaking joints with new materials and repeat test until leakage is within allowed limits.
- C. Prepare reports of testing activities.

### 3.8 IDENTIFICATION

- A. Install continuous underground detectable warning tape during backfilling of trench for underground water-distribution piping. Locate below finished grade, directly over piping. Warning tape for water line shall be printed polyethylene plastic tape with a metallic core, manufactured specifically for warning and identification of buried utility lines within the limits shown on the Contract Drawings. The tape shall be of a roll type, 2" (50 mm) minimum width, and color coded for sewer (green), with warning and

identification imprinted in bold black letters continuously and repeatedly over entire length of tape. The code and letter color shall be permanent and unaffected by moisture and other substances contained in trench backfill materials. Imprinted on the tape shall be "Caution, Buried Water Line Below", or a similar message as approved by the Engineer or Owner.

- B. Permanently attach equipment nameplate or marker indicating plastic water-service piping, on main electrical meter panel.

### 3.9 CLEANING

- A. Clean and disinfect water-distribution piping as follows:
  - 1. Purge new water-distribution piping systems and parts of existing systems that have been altered, extended, or repaired before use.
  - 2. Use purging and disinfecting procedure prescribed by Tidewater Utilities Inc. Standards. or, if method is not prescribed by authorities having jurisdiction, use procedure described in NFPA 24 for flushing of piping. Flush piping system with clean, potable water until dirty water does not appear at points of outlet.
  - 3. Use purging and disinfecting procedure prescribed by and Tidewater Utilities Inc. Standards or, if method is not prescribed by authorities having jurisdiction, use procedure described in AWWA C651 or do as follows:
    - a. Fill system or part of system with water/chlorine solution containing at least 50 ppm of chlorine; isolate and allow to stand for 24 hours.
    - b. Drain system or part of system of previous solution and refill with water/chlorine solution containing at least 200 ppm of chlorine; isolate and allow to stand for 3 hours.
    - c. After standing time, flush system with clean, potable water until no chlorine remains in water coming from system.
    - d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows evidence of contamination.
- B. Prepare reports of purging and disinfecting activities.

**END OF SECTION**

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**SECTION 221313 - FACILITY SANITARY SEWERS**

**PART 1 - GENERAL**

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions, Special Provisions and the Sussex County Government County Code “Chapter 110. Water and Sewers”, as modified and added to apply to this section. In case of conflict between the standard specifications and the specifications herein, and other contract documents, the more stringent requirement shall govern only to the extent of such a conflict.

1.2 RELATED SECTIONS

- A. DeIDOT Standard Specification Section 208 - Excavation and Backfilling for Pipe Trenches

1.3 SUMMARY

- A. Section includes:
  - 1. Pipe and fittings.
  - 2. Nonpressure couplings.
  - 3. Cleanouts.
  - 4. Encasement for piping.
  - 5. Manholes.

1.4 ACTION SUBMITTALS

- A. Product Data: For expansion joints.
- B. Shop Drawings: For manholes. Include plans, elevations, sections, details, and frames and covers.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

**PART 2 - PRODUCTS**

2.1 VC PIPE AND FITTINGS

- A. PVC Sewer Piping:

1. Pipe: Per Sussex County standards.
2. Fittings: Per Sussex County standards.
3. Gaskets: Per Sussex County standards.

## 2.2 NONPRESSURE-TYPE TRANSITION COUPLINGS

- A. Per Sussex County standards.
- B. Sleeve Materials:
  1. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
- C. Unshielded, Flexible Couplings:
  1. Description: Elastomeric sleeve with stainless-steel shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
- D. Ring-Type, Flexible Couplings: Elastomeric compression seal with dimensions to fit inside bell of larger pipe and for spigot of smaller pipe to fit inside ring.

## 2.3 CLEANOUTS

- A. Cast-Iron Cleanouts: Per Sussex County standards.

## 2.4 ENCASEMENT FOR PIPING

- A. Standard: Per Sussex County standards.
- B. Material: Per Sussex County standards.
- C. Form: Per Sussex County standards.
- D. Color: Per Sussex County standards.

## 2.5 MANHOLES

- A. Standard Precast Concrete Manholes:
  1. Per Sussex County standards.
- B. Manhole Frames and Covers:
  1. Per Sussex County standards.

## 2.6 CONCRETE

- A. General: Cast-in-place concrete complying with ACI 318, ACI 350/350R, and the following:
  - 1. Cement: ASTM C 150, Type II.
  - 2. Fine Aggregate: ASTM C 33, sand.
  - 3. Coarse Aggregate: ASTM C 33, crushed gravel.
  - 4. Water: Potable.
- B. Portland Cement Design Mix: 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio.
  - 1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
  - 2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.
- C. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.
  - 1. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.
    - a. Invert Slope: 2 percent through manhole.
  - 2. Benches: Concrete, sloped to drain into channel.
    - a. Slope: 4 percent.
- D. Ballast and Pipe Supports: Portland cement design mix, 3000 psi minimum, with 0.58 maximum water/cementitious materials ratio.
  - 1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
  - 2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 deformed steel.

## PART 3 - EXECUTION

### 3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in DeIDOT Standard Section 208 "Excavation and Backfilling for Pipe Trenches."

### 3.2 PIPING INSTALLATION

- A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground sanitary sewer piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
- B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.
- C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
- D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
- E. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.
- F. Install gravity-flow, nonpressure, drainage piping according to the following:
  - 1. Install piping pitched down in direction of flow, at minimum slope of 2 percent unless otherwise indicated.
  - 2. Install piping **NPS 6** and larger with restrained joints at tee fittings and at changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place-concrete supports or anchors.
  - 3. Install hub-and-spigot, cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
  - 4. Install hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
  - 5. Install PVC corrugated sewer piping according to ASTM D 2321 and ASTM F 1668.
  - 6. Install PVC Type PSM sewer piping according to ASTM D 2321 and ASTM F 1668.
  - 7. Install nonreinforced-concrete sewer piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."

8. Install reinforced-concrete sewer piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."
- G. Install corrosion-protection piping encasement over the following underground metal piping according to ASTM A 674 or AWWA C105:
1. Hub-and-spigot, cast-iron soil pipe.
  2. Hubless cast-iron soil pipe and fittings.
  3. Expansion joints.
- H. Clear interior of piping and manholes of dirt and superfluous material as work progresses. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.

### 3.3 PIPE JOINT CONSTRUCTION

- A. Join gravity-flow, nonpressure, drainage piping according to the following:
1. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
  2. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.
  3. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.
  4. Join PVC corrugated sewer piping according to ASTM D 2321.
  5. Join PVC Type PSM sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric-gasket joints.
  6. Join nonreinforced-concrete sewer piping according to ASTM C 14 and ACPA's "Concrete Pipe Installation Manual" for rubber-gasket joints.
  7. Join reinforced-concrete sewer piping according to ACPA's "Concrete Pipe Installation Manual" for rubber-gasket joints.
  8. Join dissimilar pipe materials with nonpressure-type, flexible couplings.
- B. Pipe couplings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
1. Use nonpressure flexible couplings where required to join gravity-flow, nonpressure sewer piping unless otherwise indicated.
    - a. Unshielded flexible couplings for pipes of same or slightly different OD.

- b. Unshielded, increaser/reducer-pattern, flexible couplings for pipes with different OD.
- c. Ring-type flexible couplings for piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.

### 3.4 MANHOLE INSTALLATION

- A. General: Install manholes complete with appurtenances and accessories indicated.
- B. Install precast concrete manhole sections with sealants according to ASTM C 891.
- C. Install FRP manholes according to manufacturer's written instructions.
- D. Form continuous concrete channels and benches between inlets and outlet.
- E. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches above finished surface elsewhere unless otherwise indicated.
- F. Install manhole-cover inserts in frame and immediately below cover.

### 3.5 CONCRETE PLACEMENT

- A. Place cast-in-place concrete according to ACI 318.

### 3.6 CLEANOUT INSTALLATION

- A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts, and use cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.
  - 1. Use Light-Duty, top-loading classification cleanouts in earth or unpaved foot-traffic areas.
  - 2. Use Medium-Duty, top-loading classification cleanouts in paved foot-traffic areas.
  - 3. Use Heavy-Duty, top-loading classification cleanouts in vehicle-traffic service areas.
- B. Set cleanout frames and covers in earth in cast-in-place-concrete block, 18 by 18 inches 4" deep. Set with tops 1 inch above surrounding grade.
- C. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.

### 3.7 CONNECTIONS

- A. Connect nonpressure, gravity-flow drainage piping to building's sanitary building drains.
- B. Make connections to existing piping and underground manholes.
  - 1. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye fitting plus 6-inch overlap with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.
  - 2. Make branch connections from side into existing piping, NPS 4 to NPS 20. Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.
  - 3. Make branch connections from side into existing piping, NPS 21 or larger, or to underground manholes by cutting opening into existing unit large enough to allow 3 inches of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of and be flush with inside wall unless otherwise indicated. On outside of pipe or manhole wall, encase entering connection in 6 inches of concrete for minimum length of 12 inches to provide additional support of collar from connection to undisturbed ground.
    - a. Use concrete that will attain a minimum 28-day compressive strength of 3000 psi unless otherwise indicated.
    - b. Use epoxy-bonding compound as interface between new and existing concrete and piping materials.
  - 4. Protect existing piping and manholes to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

### 3.8 IDENTIFICATION

- A. Arrange for installation of green warning tapes directly over piping and at outside edges of underground manholes.
  - 1. Use warning tape or detectable warning tape over ferrous piping.
  - 2. Use detectable warning tape over nonferrous piping and over edges of underground manholes.

### 3.9 FIELD QUALITY CONTROL

- A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.
  - 1. Submit separate report for each system inspection.
  - 2. Defects requiring correction include the following:
    - a. Alignment: Less than full diameter of inside of pipe is visible between structures.
    - b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
    - c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
    - d. Infiltration: Water leakage into piping.
    - e. Exfiltration: Water leakage from or around piping.
  - 3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
  - 4. Reinspect and repeat procedure until results are satisfactory.
- B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
  - 1. Do not enclose, cover, or put into service before inspection and approval.
  - 2. Test completed piping systems according to requirements of authorities having jurisdiction.
  - 3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
  - 4. Submit separate report for each test.
  - 5. Hydrostatic Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction and the following:
    - a. Fill sewer piping with water. Test with pressure of at least 10-foot head of water, and maintain such pressure without leakage for at least 15 minutes.
    - b. Close openings in system and fill with water.
    - c. Purge air and refill with water.
    - d. Disconnect water supply.
    - e. Test and inspect joints for leaks.
  - 6. Air Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction, UNI-B-6, and the following:
    - a. Option: Test plastic gravity sewer piping according to ASTM F 1417.
    - b. Option: Test concrete gravity sewer piping according to ASTM C 924.

7. Manholes: Perform hydraulic test according to ASTM C 969.

C. Leaks and loss in test pressure constitute defects that must be repaired.

D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.10 CLEANING

A. Clean dirt and superfluous material from interior of piping. Flush with potable water.

**END OF SECTION**

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## SECTION 221413 - FACILITY STORM DRAINAGE PIPING

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Pipe, tube, and fittings.
  - 2. Specialty pipe fittings.

#### 1.2 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:
  - 1. Storm Drainage Piping: **10-foot head of water.**
- B. Seismic Performance: Storm drainage piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

#### 1.3 ACTION SUBMITTALS

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

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For storm drainage piping, accessories, and components, from manufacturer.
  - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - 2. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Field quality-control reports.

#### 1.5 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF/ANSI 14, "Plastics Piping System Components and Related Materials," for plastic piping components. Include marking with "NSF-drain" for plastic drain piping and "NSF-sewer" for plastic sewer piping.

## **PART 2 - PRODUCTS**

### **2.1 PIPING MATERIALS**

- A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

### **2.2 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS**

- A. Pipe and Fittings: ASTM A 74, Extra Heavy classes.
- B. Gaskets: ASTM C 564, rubber.

### **2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS**

- A. Pipe and Fittings: ASTM A 888 or CISPI 301.
- B. Heavy-Duty, Hubless-Piping Couplings:
  - 1. Manufacturers: Subject to compliance with requirements, provide products buy one of the following:
    - a. ANACO-Husky
    - b. Clamp-All Corp.
    - c. Mission Rubber Company
  - 2. Standards: ASTM C 1277 and ASTM C 1540.
  - 3. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

### **2.4 COPPER TUBE AND FITTINGS**

- A. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.
- B. Copper Drainage Fittings: ASME B16.23, cast-copper fittings or ASME B16.29, wrought-copper, solder-joint fittings.
- C. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.

### **2.5 SPECIALTY PIPE FITTINGS**

- A. Transition Couplings:
  - 1. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections same size as and compatible with pipes to be joined.
  - 2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified-piping-system fitting.

3. Shielded, Nonpressure Transition Couplings:
  - a. Manufacturers: Subject to compliance with requirements, provide products buy one of the following:
    - 1) Cascade Waterworks Mfg. Co.
    - 2) Mission Rubber Company
  - b. Standard: ASTM C 1460.
  - c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

### **PART 3 - EXECUTION**

#### **3.1 PIPING INSTALLATION**

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations from layout are approved on coordination drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

- K. Lay buried building storm drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.
- L. Install storm drainage piping at the following minimum slopes unless otherwise indicated:
  - 1. Building Storm Drain: 1 percent downward in direction of flow for piping.
  - 2. Horizontal Storm-Drainage Piping: 1 percent downward in direction of flow.
- M. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
- N. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

### 3.2 JOINT CONSTRUCTION

- A. Hub-and-Spigot, Cast-Iron Soil Piping Gasketed Joints: Join according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
- B. Hubless, Cast-Iron Soil Piping Coupled Joints: Join according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.
- C. Join copper tube and fittings with soldered joints according to ASTM B 828 procedure. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.

### 3.3 SPECIALTY PIPE FITTING INSTALLATION

- A. Transition Couplings:
  - 1. Install transition couplings at joints of piping with small differences in OD's.
  - 2. In Drainage Piping: Shielded, nonpressure transition couplings.

### 3.4 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.

- C. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
- D. Make connections according to the following unless otherwise indicated:
  - 1. Install unions, in piping **NPS 2** and smaller, adjacent to each valve and at final connection to each piece of equipment.
  - 2. Install flanges, in piping **NPS 2-1/2** and larger, adjacent to flanged valves and at final connection to each piece of equipment.

### 3.5 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
  - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
  - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
  - 1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
  - 2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
  - 3. Test Procedure: Test storm drainage piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than **10-foot head of water**. From 15 minutes before inspection starts until completion of inspection, water level must not drop. Inspect joints for leaks.
  - 4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
  - 5. Prepare reports for tests and required corrective action.

3.6 CLEANING

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.7 PIPING SCHEDULE

- A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.
- B. Aboveground storm drainage piping **NPS 6** and smaller shall be any of the following:
  - 1. Hubless, cast-iron soil pipe and fittings; heavy-duty, hubless-piping couplings; and coupled joints.
  - 2. Copper DWV tube, copper drainage fittings, and soldered joints.
  - 3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.
- C. Aboveground, storm drainage piping **NPS 8** and larger shall be any of the following:
  - 1. Hubless, cast-iron soil pipe and fittings; heavy-duty, hubless-piping couplings; and coupled joints.
  - 2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.
- D. Underground storm drainage piping **NPS 8** and smaller shall be the following:
  - 1. Extra Heavy class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
  - 2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

**END OF SECTION**

**SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES**

**PART 1 - GENERAL**

1.1 SUMMARY

A. Section Includes:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.

B. Related Requirements:

1. Section 281300 "Security and Access Control Systems" for security access control.

1.2 DEFINITIONS

A. VFC: Variable frequency controller.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

**PART 2 - PRODUCTS**

2.1 CONDUCTORS AND CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work:

1. General Cable Technologies Corporation.
2. Southwire Incorporated.

- B. Copper Conductors: Comply with NEMA WC 70/ICEA S-95-658.
- C. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Type THHN-2-THWN-2 and Type XHHW-2.

## 2.2 CONNECTORS AND SPLICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work:
  - 1. AFC Cable Systems, Inc.
  - 2. Gardner Bender.
  - 3. Hubbell Power Systems, Inc.
  - 4. O-Z/Gedney; a brand of the EGS Electrical Group.
- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

## 2.3 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.

# **PART 3 - EXECUTION**

## 3.1 CONDUCTOR MATERIAL APPLICATIONS

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

## 3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type THHN-2-THWN-2, single conductors in raceway.
- B. Exposed Feeders: Type THHN-2-THWN-2, single conductors in raceway.
- C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-2-THWN-2, single conductors in raceway.
- D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway.

- E. Exposed Branch Circuits, Including in Crawlspace: Type THHN-2-THWN-2, single conductors in raceway.
- F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-2-THWN-2, single conductors in raceway.
- G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway.
- H. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- I. Cable from VFD to Motor: XHHW-2.

### 3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
- B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.
- C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

### 3.4 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.5 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."
- B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: Perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  - 1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors and conductors feeding the following critical equipment and services for compliance with requirements.
  - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - 3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.
    - a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
    - b. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- D. Test and Inspection Reports: Prepare a written report to record the following:

1. Procedures used.
  2. Results that comply with requirements.
  3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- E. Cables will be considered defective if they do not pass tests and inspections.

**END OF SECTION**

## SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section includes grounding and bonding systems and equipment, plus the following special applications:
  - 1. Underground distribution grounding.
  - 2. Ground bonding common with lightning protection system.
  - 3. Foundation steel electrodes.

#### 1.2 ACTION SUBMITTALS

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

#### 1.3 INFORMATIONAL SUBMITTALS

- A. As-Built Data: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:
  - 1. Test wells.
  - 2. Ground rods.
  - 3. Ground rings.
- B. Qualification Data: For testing agency and testing agency's field supervisor.
- C. Field quality-control reports.

#### 1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.
  - 1. In addition to items specified in DelDot Standard Specification, include the following:
    - a. Instructions for periodic testing and inspection of grounding features at test wells based on NFPA 70B.
      - 1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
      - 2) Include recommended testing intervals.

## 1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work:
  - 1. Burndy; Part of Hubbell Electrical Systems.
  - 2. ERICO International Corporation.
  - 3. Galvan Industries, Inc.; Electrical Products Division, LLC.
  - 4. O-Z/Gedney; A Brand of the EGS Electrical Group.
  - 5. Siemens Power Transmission & Distribution, Inc.

### 2.2 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

### 2.3 CONDUCTORS

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

- C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

## 2.4 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- D. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

## 2.5 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel, sectional type; 3/4 inch by 10 feet.

# PART 3 - EXECUTION

## 3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.
  - 1. Bury at least 24 inches below grade.
  - 2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.
- C. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
  - 1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
  - 2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.
- D. Conductor Terminations and Connections:
  - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.

2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

### 3.2 GROUNDING AT THE SERVICE

- A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

### 3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements.
- B. Grounding Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.

### 3.4 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
  1. Feeders and branch circuits.
  2. Lighting circuits.
  3. Receptacle circuits.
  4. Single-phase motor and appliance branch circuits.
  5. Three-phase motor and appliance branch circuits.
  6. Flexible raceway runs.
- C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

- E. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.
- F. Metallic Fences: Comply with requirements of IEEE C2.
  - 1. Grounding Conductor: Bare copper, not less than No. 8 AWG.
  - 2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
  - 3. Barbed Wire: Strands shall be bonded to the grounding conductor.

### 3.5 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.
  - 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
  - 2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- C. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches deep, with cover.
  - 1. Test Wells: Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
  - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
  - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
  - 3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.
- E. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
  2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
  3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- F. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.
- G. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.
- H. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of building area or item indicated.
1. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.
  2. Bury ground ring not less than 24 inches from building's foundation.
- I. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.
1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.
  2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

### 3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Perform tests and inspections.
- B. Tests and Inspections:
1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.

2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
  3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells. Make tests at ground rods before any conductors are connected.
    - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    - b. Perform tests by fall-of-potential method according to IEEE 81.
  4. Prepare dimensioned Drawings locating each test well, 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.
- C. Grounding system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. Report measured ground resistances that exceed the following values:
1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
  2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
  3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
  4. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).
  5. Substations and Pad-Mounted Equipment: 5 ohms.
  6. Handhole Grounds: 10 ohms.
- F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.

**END OF SECTION**

## **SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

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

#### **1.2 DEFINITIONS**

- A. EMT: Electrical metallic tubing.
- B. IMC: Intermediate metal conduit.
- C. RMC: Rigid metal conduit.

#### **1.3 PERFORMANCE REQUIREMENTS**

- A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

#### **1.4 ACTION SUBMITTALS**

- A. Product Data: For the following:
  - 1. Steel slotted support systems.
- B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:
  - 1. Trapeze hangers. Include Product Data for components.
  - 2. Steel slotted channel systems. Include Product Data for components.
  - 3. Equipment supports.

1.5 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.6 QUALITY ASSURANCE

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

1.7 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified together with concrete Specifications.

**PART 2 - PRODUCTS**

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
  - 1. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - a. Allied Tube & Conduit.
    - b. Cooper B-Line, Inc.
    - c. ERICO International Corporation.
    - d. Thomas & Betts Corporation.
    - e. Unistrut; Atkore International.
  - 2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
  - 3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
  - 4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
  - 5. Channel Dimensions: Selected for applicable load criteria.

6. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
  7. Fitting and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.
  8. Rated Strength: Selected to suit applicable load criteria.
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
- E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
    - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      - 1) Hilti, Inc.
      - 2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
      - 3) MKT Fastening, LLC.
      - 4) Simpson Strong-Tie Co., Inc.
  2. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

- a. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1) Cooper B-Line, Inc.
  - 2) Empire Tool and Manufacturing Co., Inc.
  - 3) Hilti, Inc.
  - 4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
  - 5) MKT Fastening, LLC.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

## 2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

## PART 3 - EXECUTION

### 3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
  - 1. Secure raceways and cables to these supports with two-bolt conduit clamps.
- D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

### 3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
  - 1. To Wood: Fasten with lag screws or through bolts.
  - 2. To New Concrete: Bolt to concrete inserts.
  - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
  - 4. To Existing Concrete: Expansion anchor fasteners.
  - 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
  - 6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
  - 7. To Light Steel: Sheet metal screws.

8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

### 3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

### 3.4 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."
- C. Anchor equipment to concrete base.
  1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  2. Install anchor bolts to elevations required for proper attachment to supported equipment.
  3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

### 3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Touchup: Comply with requirements in Section 099113 "Exterior Painting" Section 099123 "Interior Painting" and for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

**END OF SECTION 260529**

## **SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

**A. Section Includes:**

1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Metal wireways and auxiliary gutters.
4. Surface raceways.
5. Boxes, enclosures, and cabinets.
6. Handholes and boxes for exterior underground cabling.

**B. Related Requirements:**

1. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
2. Section 280528 "Pathways for Electronic Safety and Security" for conduits, surface pathways, innerduct, boxes, and faceplate adapters serving electronic safety and security.

#### **1.2 DEFINITIONS**

**A. GRC:** Galvanized rigid steel conduit.

**B. IMC:** Intermediate metal conduit.

#### **1.3 ACTION SUBMITTALS**

**A. Product Data:** For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

**B. LEED Submittals:**

1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.

**C. Shop Drawings:** For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

#### **1.4 INFORMATIONAL SUBMITTALS**

**A. Coordination Drawings:** Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

B. Source quality-control reports.

## **PART 2 - PRODUCTS**

### **2.1 METAL CONDUITS, TUBING, AND FITTINGS**

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

1. AFC Cable Systems, Inc.
2. Allied Tube & Conduit.
3. Anamet Electrical, Inc.
4. O-Z/Gedney.
5. Republic Conduit.
6. Southwire Company.
7. Thomas & Betts Corporation.
8. Wheatland Tube Company.

B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. GRC: Comply with ANSI C80.1 and UL 6.

D. ARC: Comply with ANSI C80.5 and UL 6A.

E. IMC: Comply with ANSI C80.6 and UL 1242.

F. EMT: Comply with ANSI C80.3 and UL 797.

G. FMC: Comply with UL 1; zinc-coated steel or aluminum.

H. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

I. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
2. Fittings for EMT:
  - a. Material: Steel or die cast.
  - b. Type: Setscrew or compression.

3. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
- J. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

## 2.2 NONMETALLIC CONDUITS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. AFC Cable Systems, Inc.
  2. Arco Corporation.
  3. Condux International, Inc.
  4. Electri-Flex Company.
  5. Lamson & Sessions; Carlon Electrical Products.
  6. RACO; Hubbell.
  7. Thomas & Betts Corporation.
- B. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- D. LFNC: Comply with UL 1660.
- E. Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
- F. Fittings for LFNC: Comply with UL 514B.
- G. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

## 2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. Cooper B-Line, Inc.
  2. Hoffman.
  3. Mono-Systems, Inc.

4. Square D.
- B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 12 unless otherwise indicated, and sized according to NFPA 70.
  1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Hinged type unless otherwise indicated.
- E. Finish: Manufacturer's standard enamel finish.

#### 2.4 SURFACE RACEWAYS

- A. Listing and Labeling: Surface raceways shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect.
  1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Mono-Systems, Inc.
    - b. Panduit Corp.
    - c. Wiremold / Legrand.

#### 2.5 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. Cooper Technologies Company; Cooper Crouse-Hinds.
  2. EGS/Appleton Electric.
  3. Hoffman.
  4. Hubbell Incorporated.
  5. O-Z/Gedney.
  6. RACO; Hubbell.
  7. Thomas & Betts Corporation.
  8. Wiremold / Legrand.

- B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- E. Metal Floor Boxes:
  - 1. Material: Cast metal or sheet metal.
  - 2. Type: Fully adjustable.
  - 3. Shape: Rectangular.
  - 4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- F. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.
- G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- H. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.
- I. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- J. Gangable boxes are allowed.
- K. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 12 with continuous-hinge cover with flush latch unless otherwise indicated.
  - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
  - 2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- L. Cabinets:
  - 1. NEMA 250, Type 12 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
  - 2. Hinged door in front cover with flush latch and concealed hinge.
  - 3. Key latch to match panelboards.
  - 4. Metal barriers to separate wiring of different systems and voltage.
  - 5. Accessory feet where required for freestanding equipment.

## 2.6 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

- A. General Requirements for Handholes and Boxes:
1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
  2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Armorcast Products Company.
    - b. Carson Industries LLC.
    - c. NewBasis.
    - d. Oldcastle Precast, Inc.
    - e. Quazite: Hubbell Power System, Inc.
    - f. Synertech Moulded Products.
  2. Standard: Comply with SCTE 77.
  3. Configuration: Designed for flush burial with closed bottom unless otherwise indicated.
  4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
  5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
  6. Cover Legend: Molded lettering, "ELECTRIC" or "COMMUNICATION".
  7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
  8. Handholes 12 Inches Wide by 24 Inches Long and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

## 2.7 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

- A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
  - 1. Tests of materials shall be performed by an independent testing agency.
  - 2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
  - 3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

## PART 3 - EXECUTION

### 3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
  - 1. Exposed Conduit: GRC.
  - 2. Concealed Conduit, Aboveground: GRC.
  - 3. Underground Conduit: RNC, Type EPC-40-PVC.
  - 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
  - 5. Boxes and Enclosures, Aboveground: NEMA 250, Type 4.
- B. Indoors: Apply raceway products as specified below unless otherwise indicated:
  - 1. Exposed, Not Subject to Physical Damage: EMT.
  - 2. Exposed, Not Subject to Severe Physical Damage: EMT.
  - 3. Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:
    - a. Loading dock.
    - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
    - c. Mechanical rooms.
    - d. Shops.
  - 4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
  - 5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
  - 6. Damp or Wet Locations: GRC.
  - 7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in damp or wet locations.

- C. Minimum Raceway Size: 3/4-inch trade size.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
  - 1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
  - 2. EMT: Use setscrew or compression, steel fittings. Comply with NEMA FB 2.10.
  - 3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
- E. Do not install aluminum, boxes, or fittings in contact with concrete or earth.
- F. Install surface raceways only where indicated on Drawings.
- G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

### 3.2 INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
- B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- C. Complete raceway installation before starting conductor installation.
- D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- E. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- F. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- H. Support conduit within 12 inches of enclosures to which attached.
- I. Raceways Embedded in Slabs are not allowed:
- J. Stub-ups to Above Recessed Ceilings:
  - 1. Use EMT, IMC, or RMC for raceways.

2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- K. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
  - L. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.
  - M. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
  - N. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
  - O. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
  - P. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.
  - Q. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
  - R. Surface Raceways:
    1. Install surface raceway with a minimum 2-inch radius control at bend points.
    2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.
  - S. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

- T. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
  2. Where an underground service raceway enters a building or structure.
  3. Where otherwise required by NFPA 70.
- U. Comply with manufacturer's written instructions for solvent welding RNC and fittings.
- V. Expansion-Joint Fittings:
1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
  2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
    - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
    - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
    - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
    - d. Attics: 135 deg F temperature change.
  3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
  4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
  5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- W. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
  2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
- X. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.
- Y. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.
- Z. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- AA. Locate boxes so that cover or plate will not span different building finishes.
- BB. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- CC. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- DD. Set metal floor boxes level and flush with finished floor surface.
- EE. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

### 3.3 INSTALLATION OF UNDERGROUND CONDUIT

- A. Direct-Buried Conduit:
1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in DelDot Standard Specification 208, for pipe less than 6 inches in nominal diameter.
  2. Install backfill as specified in DelDot Standard Specification 208.
  3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in DelDot Standard Specification 208.
  4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.

5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
  - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete for a minimum of 12 inches on each side of the coupling.
  - b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
6. Warning Planks: Bury warning planks approximately 12 inches above direct-buried conduits but a minimum of 6 inches below grade. Align planks along centerline of conduit.
7. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

#### 3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.
- D. Install handholes with bottom below frost line, below grade.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables but short enough to preserve adequate working clearances in enclosure.
- F. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.6 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
  - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

**END OF SECTION**

**SECTION 260543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS**

**PART 1 - GENERAL**

**1.1 SUMMARY**

**A. Section Includes:**

1. Direct-buried conduit, ducts, and duct accessories.
2. Concrete-encased conduit, ducts, and duct accessories.
3. Handholes and boxes.

**1.2 DEFINITIONS**

- A. Trafficways:** Locations where vehicular or pedestrian traffic is a normal course of events.

**1.3 ACTION SUBMITTALS**

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

1. Include duct-bank materials, including separators and miscellaneous components.
2. Include ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Include accessories for handholes, boxes, and other utility structures.
4. Include warning tape.
5. Include warning planks.

**B. Shop Drawings:**

1. Precast or Factory-Fabricated Underground Utility Structures:
  - a. Include plans, elevations, sections, details, attachments to other work, and accessories.
  - b. Include duct entry provisions, including locations and duct sizes.
  - c. Include reinforcement details.
  - d. Include frame and cover design and manhole frame support rings.
  - e. Include Ladder details.
  - f. Include grounding details.
  - g. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
  - h. Include joint details.
2. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:

- a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
- b. Include duct entry provisions, including locations and duct sizes.
- c. Include cover design.
- d. Include grounding details.
- e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.
  1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
  2. Drawings shall be signed and sealed by a qualified professional engineer.
- B. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C 858.
- C. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.
- D. Source quality-control reports.
- E. Field quality-control reports.

#### 1.5 MAINTENANCE MATERIALS SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Furnish cable-support stanchions, arms, insulators, and associated fasteners in quantities equal to 5 percent of quantity of each item installed.

#### 1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

#### 1.7 FIELD CONDITIONS

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions, and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of electrical service.
  2. Do not proceed with interruption of electrical service without Owner's written permission.
- B. Ground Water: Assume ground-water level is at grade level unless a lower water table is noted on Drawings.

## **PART 2 - PRODUCTS**

### **2.1 GENERAL REQUIREMENTS FOR DUCTS AND RACEWAYS**

- A. Comply with ANSI C2.

### **2.2 CONDUIT**

- A. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.
- B. RNC: NEMA TC 2, Type EPC-40-PVC and Type EPC-80-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

### **2.3 NONMETALLIC DUCTS AND DUCT ACCESSORIES**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. ARNCO Corp.
  2. Beck Manufacturing.
  3. Cantex, Inc.
  4. CertainTeed Corporation.
  5. Condux International, Inc.
  6. ElecSys, Inc.
  7. Electri-Flex Company.
  8. IPEX Inc.
  9. Lamson & Sessions; Carlon Electrical Products.
  10. Spiraduct/AFC Cable Systems, Inc.
- B. Underground Plastic Utilities Duct: NEMA TC 2, UL 651, ASTM F 512, Type EPC-80 and Type EPC-40, with matching fittings complying with NEMA TC 3 by same manufacturer as the duct.
- C. Duct Accessories:
1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and size of ducts with which used, and selected to provide

minimum duct spacing indicated while supporting ducts during concreting or backfilling.

2. Warning Tape: Underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."
3. Concrete Warning Planks: Nominal 12 by 24 by 3 inches in size, manufactured from 6000-psi concrete.
  - a. Color: Red dye added to concrete during batching.
  - b. Mark each plank with "ELECTRIC" in 2-inch- high, 3/8-inch- deep letters.

## 2.4 HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. General Requirements for Handholes and Boxes: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.

1. Color: Gray.
2. Configuration: Units shall be designed for flush burial and have closed bottom unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering, As indicated for each service.
6. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
7. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
8. Handholes 12 inches wide by 24 inches long and larger shall have factory-installed inserts for cable racks and pulling-in irons.

B. Polymer Concrete Handholes and Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - a. Armorcast Products Company.
  - b. Carson Industries LLC.
  - c. NewBasis.

- d. Quazite: Hubbell Power System, Inc.

## 2.5 UTILITY STRUCTURE ACCESSORIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Bilco Company (The).
  2. Campbell Foundry Company.
  3. Christy Concrete Products.
  4. East Jordan Iron Works, Inc.
  5. Elmhurst-Chicago Stone Co.
  6. McKinley Iron Works, Inc.
  7. Neenah Foundry Company.
  8. NewBasis.
  9. Oldcastle Precast Group.
  10. Osburn Associates, Inc.
  11. Pennsylvania Insert Corporation.
  12. Quazite:Hubbell Power Systems, Inc.
  13. Rinker Group, Ltd.
  14. Riverton Concrete Products.
  15. Underground Devices, Inc.
  16. Utility Concrete Products, LLC.
  17. Utility Vault Co.
  18. Wausau Tile Inc.
- B. Handhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for handhole.
1. Frame and Cover: Weatherproof.
    - a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
    - b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.
  2. Cover Legend: Cast in. Selected to suit system.
    - a. Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
    - b. Legend: "COMMUNICATION" for duct systems with fiber and control cables.
- C. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch- diameter eye, and 1-by-4-inch bolt.

1. Working Load Embedded in 6-Inch, 4000-psi Concrete: 13,000-lbf minimum tension.
- D. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1-1/4-inch-diameter eye, rated 2500-lbf minimum tension.
- E. Pulling-In and Lifting Irons in Concrete Floors: 7/8-inch-diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.
  1. Ultimate Yield Strength: 40,000-lbf shear and 60,000-lbf tension.
- F. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch ID by 2-3/4 inches deep, flared to 1-1/4 inches minimum at base.
  1. Tested Ultimate Pullout Strength: 12,000 lbf minimum.
- G. Ground Rod Sleeve: 3-inch, PVC conduit sleeve in manhole floors 2 inches from the wall adjacent to, but not underneath, the ducts routed from the facility.
- H. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch bolt, 5300-lbf rated pullout strength, and minimum 6800-lbf rated shear strength.
- I. Cable Rack Assembly: Steel, hot-dip galvanized, except insulators.
  1. Stanchions: T-section or channel; 2-1/4-inch nominal size; punched with 14 holes on 1-1/2-inch centers for cable-arm attachment.
  2. Arms: 1-1/2 inches wide, lengths ranging from 3 inches with 450-lb minimum capacity to 18 inches with 250-lb minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.
  3. Insulators: High-glaze, wet-process porcelain arranged for mounting on cable arms.
- J. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.
  1. Stanchions: Nominal 36 inches high by 4 inches wide, with minimum of nine holes for arm attachment.
  2. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3 inches with 450-lb minimum capacity to 20 inches with 250-lb minimum capacity. Top of arm shall be nominally 4 inches wide, and arm shall have slots along full length for cable ties.

- K. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F. Capable of withstanding temperature of 300 deg F without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.
- L. Cover Hooks: Heavy duty, designed for lifts 60 lbf and greater. Two required.

## 2.6 SOURCE QUALITY CONTROL

- A. Test and inspect precast concrete utility structures according to ASTM C 1037.
- B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
  - 1. Tests of materials shall be performed by an independent testing agency.
  - 2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
  - 3. Testing machine pressure gages shall have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

## PART 3 - EXECUTION

### 3.1 PREPARATION

- A. Coordinate layout and installation of ducts, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.
- B. Coordinate elevations of ducts and duct-bank entrances into handholes, and boxes with final locations and profiles of ducts and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct runs drain to handholes and as approved by Architect.

- 3.2 Clear and grub vegetation to be removed, and protect vegetation to remain according to DeIDot Standard Specification. Remove and stockpile topsoil for reapplication according to DeIDot Standard Specification.

### 3.3 UNDERGROUND DUCT APPLICATION

- A. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-40-PVC, in concrete-encased duct bank unless otherwise indicated.

- B. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank unless otherwise indicated.
- C. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank unless otherwise indicated.
- D. Underground Ducts Crossing Paved Paths, Driveways and Roadways: RNC, NEMA Type EPC-40-PVC, encased in reinforced concrete.

### 3.4 UNDERGROUND ENCLOSURE APPLICATION

- A. Handholes and Boxes for 600 V and Less:
  - 1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete, AASHTO HB 17, H-10 structural load rating.
  - 2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.
  - 3. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Precast concrete, AASHTO HB 17, H-10 structural load rating.
  - 4. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf vertical loading.
  - 5. Cover design load shall not exceed the design load of the handhole or box.

### 3.5 EARTHWORK

- A. Excavation and Backfill: Comply with DelDot Standard Specification 208, but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
- C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary top soiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with DelDot Standard Specification 208.
- D. Cut and patch existing pavement in the path of underground ducts and utility structures according to the DelDot Standard Specification 208.

### 3.6 DUCT INSTALLATION

- A. Install ducts according to NEMA TCB 2.

- B. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes, to drain in both directions.
- C. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches, both horizontally and vertically, at other locations unless otherwise indicated.
- D. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.
- E. Installation Adjacent to High-Temperature Steam Lines: Where duct banks are installed parallel to underground steam lines, perform calculations showing the duct bank will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct bank crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.
- F. Duct Entrances to Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch ducts, and vary proportionately for other duct sizes.
  - 1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell without reducing duct line slope and without forming a trap in the line.
  - 2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line direct-buried duct banks with calculated expansion of more than 3/4 inch.
  - 3. Grout end bells into structure walls from both sides to provide watertight entrances.
- G. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 10 feet outside the building wall, without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
- H. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.
- I. Pulling Cord: Install 100-lbf- test nylon cord in empty ducts.
- J. Concrete-Encased Ducts: Support ducts on duct separators.

1. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in DelDot Standard Specification for pipes less than 6 inches in nominal diameter.
2. Width: Excavate trench 12 inches wider than duct bank on each side.
3. Width: Excavate trench 3 inches wider than duct bank on each side.
4. Depth: Install top of duct bank at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 30 inches below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
5. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
6. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than four spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
7. Minimum Space between Ducts: 3 inches between ducts and exterior envelope wall, 2 inches between ducts for like services, and 4 inches between power and signal ducts.
8. Elbows: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run.
  - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
  - b. Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.
9. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
10. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
11. Concrete Cover: Install a minimum of 3 inches of concrete cover at top and bottom, and a minimum of 2 inches on each side of duct bank.
12. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
  - a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to

manufacturer's written recommendations, or use other specific measures to prevent expansion-contraction damage.

- b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing-rod dowels extending a minimum of 18 inches into concrete on both sides of joint near corners of envelope.

13. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 033000 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.

K. Direct-Buried Duct Banks:

1. Excavate trench bottom to provide firm and uniform support for duct bank. Comply with requirements in DelDot Standard Specification for preparation of trench bottoms for pipes less than 6 inches in nominal diameter.
2. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
3. Space separators close enough to prevent sagging and deforming of ducts, with not less than four spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches between tiers.
4. Depth: Install top of duct bank at least 36 inches below finished grade unless otherwise indicated.
5. Set elevation of bottom of duct bank below frost line.
6. Install ducts with a minimum of 3 inches between ducts for like services and 6 inches between power and signal ducts.
7. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run.
  - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
  - b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
8. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this

process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inches over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in DelDot Standard Specification for installation of backfill materials.

- a. Place minimum 3 inches of sand as a bed for duct bank. Place sand to a minimum of 6 inches above top level of duct bank.
  - b. Place minimum 6 inches of engineered fill above concrete encasement of duct bank.
- L. Warning Planks: Bury warning planks approximately 12 inches above direct-buried ducts and duct banks, placing them 24 inches o.c. Align planks along the width and along the centerline of duct bank. Provide an additional plank for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional planks 12 inches apart, horizontally.
- M. Warning Tape: Bury warning tape approximately 12 inches above all concrete-encased ducts and duct banks. Align tape parallel to and within 3 inches of centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

### 3.7 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by manufacturer.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch above finished grade.
- D. Install handholes and boxes with bottom below frost line, below grade.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.

- F. Field cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
- G. For enclosures installed in asphalt paving and Insert material and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.
  - 1. Concrete: 3000 psi, 28-day strength, complying with Section 033000 "Cast-in-Place Concrete," with a troweled finish.
  - 2. Dimensions: 10 inches wide by 12 inches deep.

### 3.8 GROUNDING

- A. Ground underground ducts and utility structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

### 3.9 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections and prepare test reports:
  - 1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
  - 2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 6-inch- long mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
  - 3. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Correct deficiencies and retest as specified above to demonstrate compliance.

### 3.10 CLEANING

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.
- B. Clean internal surfaces of manholes, including sump. Remove foreign material.

**END OF SECTION**

**SECTION 260544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS  
AND CABLING**

**PART 1 - GENERAL**

1.1 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.

**PART 2 - PRODUCTS**

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

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

F. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:
  - a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
  - b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Advance Products & Systems, Inc.
  - b. CALPICO, Inc.
  - c. Metraflex Company (The).
  - d. Pipeline Seal and Insulator, Inc.
  - e. Proco Products, Inc.
2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Carbon steel Stainless steel.
4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Presealed Systems.

2.4 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

- B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

## 2.5 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
  - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
  - 2. Sealant shall have VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

## PART 3 - EXECUTION

### 3.1 INCLUDE FOR FIRE PENETRATIONS SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
  - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
    - a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint.
    - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
  - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
  - 3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
  - 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.

5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.
- D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
  2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.
- E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

### 3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
- B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

### 3.3 SLEEVE-SEAL-FITTING INSTALLATION

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

**END OF SECTION**

## **SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

- A. Section Includes:
  - 1. Identification for raceways.
  - 2. Identification of power and control cables.
  - 3. Identification for conductors.
  - 4. Underground-line warning tape.
  - 5. Warning labels and signs.
  - 6. Instruction signs.
  - 7. Equipment identification labels.
  - 8. Miscellaneous identification products.

#### **1.2 ACTION SUBMITTALS**

- A. Product Data: For each electrical identification product indicated.
- B. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.
- C. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

#### **1.3 QUALITY ASSURANCE**

- A. Comply with ANSI A13.1 and IEEE C2.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

#### **1.4 COORDINATION**

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.
- D. Install identifying devices before installing acoustical ceilings and similar concealment.

## **PART 2 - PRODUCTS**

### **2.1 POWER AND CONTROL RACEWAY IDENTIFICATION MATERIALS**

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
- B. Colors for Raceways Carrying Circuits at 600 V or Less:
  - 1. Black letters on an orange field.
  - 2. Legend: Indicate voltage and system or service type.
- C. Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing ends of legend label.

### **2.2 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS**

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each cable size.
- B. Self-Adhesive, Self-Laminating Polyester Labels: Preprinted, 3-mil- thick flexible label with acrylic pressure-sensitive adhesive that provides a clear, weather- and chemical-resistant, self-laminating, protective shield over the legend. Labels sized to fit the cable diameter such that the clear shield overlaps the entire printed legend.
- C. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of cable it identifies and to stay in place by gripping action.

### **2.3 CONDUCTOR IDENTIFICATION MATERIALS**

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

### **2.4 FLOOR MARKING TAPE**

- A. 2-inch- wide, 5-mil pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.

## 2.5 UNDERGROUND-LINE WARNING TAPE

### A. Tape:

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

### B. Color and Printing:

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

### C. Tag: Type ID:

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

## 2.6 WARNING LABELS AND SIGNS

### A. Comply with NFPA 70 and 29 CFR 1910.145.

### B. Baked-Enamel Warning Signs:

1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal size, 7 by 10 inches.

### C. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

## 2.7 INSTRUCTION SIGNS

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

## 2.8 EQUIPMENT IDENTIFICATION LABELS

- A. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

## 2.9 CABLE TIES

- A. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.
  1. Minimum Width: 3/16 inch.
  2. Tensile Strength at 73 deg F, According to ASTM D 638: 12,000 psi.
  3. Temperature Range: Minus 40 to plus 185 deg F.
  4. Color: Black except where used for color-coding.
- B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self extinguishing, one piece, self locking, Type 6/6 nylon.
  1. Minimum Width: 3/16 inch.
  2. Tensile Strength at 73 deg F, According to ASTM D 638: 12,000 psi.
  3. Temperature Range: Minus 40 to plus 185 deg F.
  4. Color: Black.
- C. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one piece, self locking.
  1. Minimum Width: 3/16 inch.
  2. Tensile Strength at 73 deg F, According to ASTM D 638: 7000 psi.
  3. UL 94 Flame Rating: 94V-0.

4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

## 2.10 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Apply identification devices to surfaces that require finish after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
- F. Attach plastic raceway and cable labels that are not self-adhesive type with clear vinyl tape with adhesive appropriate to the location and substrate.
- G. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- H. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
  1. Outdoors: UV-stabilized nylon.
  2. In Spaces Handling Environmental Air: Plenum rated.
- I. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches

below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

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

### 3.2 IDENTIFICATION SCHEDULE

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

- D. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.
- E. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive, self-laminating polyester labels with the conductor or cable designation, origin, and destination.
- F. Control-Circuit Conductor Termination Identification: For identification at terminations provide heat-shrink preprinted tubes with the conductor designation.
- G. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.
- H. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
  - 1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
  - 2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
  - 3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.
- I. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.
  - 1. Limit use of underground-line warning tape to direct-buried cables.
  - 2. Install underground-line warning tape for both direct-buried cables and cables in raceway.
- J. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- K. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels.
  - 1. Comply with 29 CFR 1910.145.
  - 2. Identify system voltage with black letters on an orange background.
  - 3. Apply to exterior of door, cover, or other access.
  - 4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:
    - a. Power transfer switches.
    - b. Controls with external control power connections.

- L. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
- M. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- high letters for emergency instructions at equipment used for power transfer.
- N. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:

- a. Engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch- high label; where two lines of text are required, use labels 2 inches high.
- b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
- c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
- d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

2. Equipment to Be Labeled:

- a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be self-adhesive, engraved, laminated acrylic or melamine label.
- b. Enclosures and electrical cabinets.
- c. Access doors and panels for concealed electrical items.
- d. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
- e. Emergency system boxes and enclosures.
- f. Enclosed switches.
- g. Enclosed circuit breakers.
- h. Enclosed controllers.
- i. Variable-speed controllers.

- j. Push-button stations.
- k. Power transfer equipment.
- l. Contactors.
- m. Remote-controlled switches, dimmer modules, and control devices.
- n. Battery-inverter units.
- o. Battery racks.
- p. Power-generating units.
- q. Monitoring and control equipment.

**END OF SECTION**

## **SECTION 260572 - OVERCURRENT PROTECTIVE DEVICE SHORT-CIRCUIT STUDY**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

- A. Section includes a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices.

#### **1.2 DEFINITIONS**

- A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.
- B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
- D. SCCR: Short-circuit current rating.
- E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

#### **1.3 ACTION SUBMITTALS**

- A. Product Data: For computer software program to be used for studies.
- B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
  - 1. Short-circuit study input data, including completed computer program input data sheets.
  - 2. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.
    - a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.
    - b. Revised single-line diagram, reflecting field investigation results and results of short-circuit study.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Short-Circuit Study Specialist.
- B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

1.5 QUALITY ASSURANCE

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.
- B. Short-Circuit Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
  - 1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- C. Short-Circuit Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

**PART 2 - PRODUCTS**

2.1 COMPUTER SOFTWARE

- A. Software Developers: Subject to compliance with requirements, provide software by one of the following:
  - 1. ESA Inc.
  - 2. Operation Technology, Inc.
  - 3. Power Analytics, Corporation.
  - 4. SKM Systems Analysis, Inc.
  - 5. Etap.

- B. Comply with IEEE 399 and IEEE 551.
- C. Analytical features of fault-current-study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
- D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output.

## 2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS

- A. Executive summary.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of the computer printout.
- C. One-line diagram, showing the following:
  - 1. Protective device designations and ampere ratings.
  - 2. Cable size and lengths.
  - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
  - 4. Motor and generator designations and kVA ratings.
  - 5. Panelboard designations.
- D. Comments and recommendations for system improvements, where needed.
- E. Protective Device Evaluation:
  - 1. Evaluate equipment and protective devices and compare to short-circuit ratings.
  - 2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
  - 3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
  - 4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
  - 5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure

that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

F. Short-Circuit Study Output:

1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
  - a. Voltage.
  - b. Calculated fault-current magnitude and angle.
  - c. Fault-point X/R ratio.
  - d. Equivalent impedance.
2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
  - a. Voltage.
  - b. Calculated symmetrical fault-current magnitude and angle.
  - c. Fault-point X/R ratio.
  - d. Calculated asymmetrical fault currents:
    - 1) Based on fault-point X/R ratio.
    - 2) Based on calculated symmetrical value multiplied by 1.6.
    - 3) Based on calculated symmetrical value multiplied by 2.7.
3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
  - a. Voltage.
  - b. Calculated symmetrical fault-current magnitude and angle.
  - c. Fault-point X/R ratio.
  - d. No AC Decrement (NACD) ratio.
  - e. Equivalent impedance.
  - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
  - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Obtain all data necessary for the conduct of the study.
  1. Verify completeness of data supplied on the one-line diagram. Call any discrepancies to the attention of Architect.

2. For equipment provided that is Work of this Project, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
  3. For relocated equipment and that which is existing to remain, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.
- B. Gather and tabulate the following input data to support the short-circuit study. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.
1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
  2. Obtain electrical power utility impedance at the service.
  3. Power sources and ties.
  4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
  5. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
  6. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
  7. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
  8. Motor horsepower and NEMA MG 1 code letter designation.
  9. Cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

### 3.2 SHORT-CIRCUIT STUDY

- A. Perform study following the general study procedures contained in IEEE 399.
- B. Calculate short-circuit currents according to IEEE 551.
- C. Base study on the device characteristics supplied by device manufacturer.
- D. Begin short-circuit current analysis at the service, extending down to the system overcurrent protective devices as follows:
  - 1. To normal system low-voltage load buses where fault current is 10 kA or less.
  - 2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.
- E. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- F. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
  - 1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
- G. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each of the following:
  - 1. Electric utility's supply termination point.
  - 2. Incoming switchboard.
  - 3. Distribution panels.
  - 4. Control panels.
  - 5. Standby generators and automatic transfer switches.
  - 6. Branch circuit panelboards.
  - 7. Disconnect switches.

3.3 ADJUSTING

- A. Make minor modifications to equipment as required to accomplish compliance with short-circuit study.

3.4 DEMONSTRATION

- A. Train Owner's operating and maintenance personnel in the use of study results.

**END OF SECTION**

**SECTION 260573 - OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.
  - 1. Study results shall be used to determine coordination of series-rated devices.

**1.2 DEFINITIONS**

- A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.
- B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
- D. SCCR: Short-circuit current rating.
- E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For computer software program to be used for studies.
- B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
  - 1. Coordination-study input data, including completed computer program input data sheets.
  - 2. Study and equipment evaluation reports.
  - 3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.
    - a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain

approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Coordination Study Specialist.
- B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

#### 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals.
  - 1. In addition to items specified in DelDot Standard Specification, include the following:
    - a. The following parts from the Protective Device Coordination Study Report:
      - 1) One-line diagram.
      - 2) Protective device coordination study.
      - 3) Time-current coordination curves.
    - b. Power system data.

#### 1.6 QUALITY ASSURANCE

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.
- B. Coordination Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
  - 1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- C. Coordination Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

- D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

## **PART 2 - PRODUCTS**

### **2.1 COMPUTER SOFTWARE DEVELOPERS**

- A. Software Developers: Subject to compliance with requirements, provide software by one of the following:
  - 1. ESA Inc.
  - 2. Operation Technology, Inc.
  - 3. Power Analytics, Corporation.
  - 4. SKM Systems Analysis, Inc.
- B. Comply with IEEE 242 and IEEE 399.
- C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
- D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.
  - 1. Other Features:
    - a. Arcing faults.
    - b. Simultaneous faults.
    - c. Explicit negative sequence.
    - d. Mutual coupling in zero sequence.

### **2.2 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS**

- A. Executive summary.
- B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.
- C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchboard and panelboard designations.

D. Short-Circuit Study:

1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
  - a. Voltage.
  - b. Calculated fault-current magnitude and angle.
  - c. Fault-point X/R ratio.
  - d. Equivalent impedance.
2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
  - a. Voltage.
  - b. Calculated symmetrical fault-current magnitude and angle.
  - c. Fault-point X/R ratio.
  - d. Calculated asymmetrical fault currents:
    - 1) Based on fault-point X/R ratio.
    - 2) Based on calculated symmetrical value multiplied by 1.6.
    - 3) Based on calculated symmetrical value multiplied by 2.7.
3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
  - a. Voltage.
  - b. Calculated symmetrical fault-current magnitude and angle.
  - c. Fault-point X/R ratio.
  - d. No AC Decrement (NACD) ratio.
  - e. Equivalent impedance.
  - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
  - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

E. Protective Device Coordination Study:

1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
  - a. Phase and Ground Relays:

- 1) Device tag.
  - 2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
  - 3) Recommendations on improved relaying systems, if applicable.
- b. Circuit Breakers:
- 1) Adjustable pickups and time delays (long time, short time, ground).
  - 2) Adjustable time-current characteristic.
  - 3) Adjustable instantaneous pickup.
  - 4) Recommendations on improved trip systems, if applicable.
- c. Fuses: Show current rating, voltage, and class.
- F. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
  2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
  3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
  4. Plot the following listed characteristic curves, as applicable:
    - a. Power utility's overcurrent protective device.
    - b. Low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
    - c. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
    - d. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
    - e. Cables and conductors damage curves.
    - f. Ground-fault protective devices.
    - g. Motor-starting characteristics and motor damage points.
    - h. Generator short-circuit decrement curve and generator damage point.
    - i. The largest feeder circuit breaker in each motor-control center and panelboard.

5. Provide adequate time margins between device characteristics such that selective operation is achieved.
6. Comments and recommendations for system improvements.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.
  1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

#### **3.2 PROTECTIVE DEVICE COORDINATION STUDY**

- A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.
- B. Comply with IEEE 399 for general study procedures.
- C. The study shall be based on the device characteristics supplied by device manufacturer.
- D. The extent of the electrical power system to be studied is indicated on Drawings.
- E. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:
  1. To normal system low-voltage load buses where fault current is 10 kA or less.
  2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.
- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- G. Transformer Primary Overcurrent Protective Devices:
  1. Device shall not operate in response to the following:
    - a. Inrush current when first energized.

- b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
    - c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
  2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.
- H. Motor Protection:
  1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
  2. Select protection for motors served at voltages more than 600 V according to IEEE 620.
- I. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.
- J. Generator Protection: Select protection according to manufacturer's written recommendations and to IEEE 242.
- K. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
  1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
- L. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:
  1. Electric utility's supply termination point.
  2. Low-voltage switchboard.
  3. Standby generators and automatic transfer switches.
  4. Branch circuit panelboards.
- M. Protective Device Evaluation:
  1. Evaluate equipment and protective devices and compare to short-circuit ratings.

2. Adequacy of switchboards, and panelboard bus bars to withstand short-circuit stresses.
3. Any application of series-rated devices shall be recertified, complying with requirements in NFPA 70.

### 3.3 POWER SYSTEM DATA

- A. Obtain all data necessary for the conduct of the overcurrent protective device study.
  1. Verify completeness of data supplied in the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
  2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
  3. For existing equipment, whether or not relocated obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.
- B. Gather and tabulate the following input data to support coordination study. The list below is a guide. Comply with recommendations in IEEE 241 and IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.
  1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
  2. Electrical power utility impedance at the service.
  3. Power sources and ties.
  4. Short-circuit current at each system bus, three phase and line-to-ground.
  5. Full-load current of all loads.
  6. Voltage level at each bus.
  7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
  8. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
  9. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
  10. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.

11. Maximum demands from service meters.
12. Motor horsepower and NEMA MG 1 code letter designation.
13. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
14. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
  - a. Special load considerations, including starting inrush currents and frequent starting and stopping.
  - b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
  - c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
  - d. Generator thermal-damage curve.
  - e. Ratings, types, and settings of utility company's overcurrent protective devices.
  - f. Special overcurrent protective device settings or types stipulated by utility company.
  - g. Time-current-characteristic curves of devices indicated to be coordinated.
  - h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
  - i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
  - j. Panelboards, switchboards, motor-control center ampacity, and SCCR in amperes rms symmetrical.
  - k. Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

### 3.4 FIELD ADJUSTING

- A. Adjust relay and protective device settings according to the recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.
- B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.

- C. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.
  - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

3.5 DEMONSTRATION

- A. Engage the Coordination Study Specialist to train Owner's maintenance personnel in the following:
  - 1. Acquaint personnel in the fundamentals of operating the power system in normal and emergency modes.
  - 2. Hand-out and explain the objectives of the coordination study, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting the time-current coordination curves.
  - 3. Adjust, operate, and maintain overcurrent protective device settings.

**END OF SECTION**

## **SECTION 260574 - OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

- A. Section includes a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

#### **1.2 DEFINITIONS**

- A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.
- B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
- D. SCCR: Short-circuit current rating.
- E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

#### **1.3 ACTION SUBMITTALS**

- A. Product Data: For computer software program to be used for studies.
- B. Other Action Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals shall be in digital form.
  - 1. Arc-flash study input data, including completed computer program input data sheets.
  - 2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.
    - a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Arc-Flash Study Specialist.
- B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.
- B. Operation and Maintenance Procedures: In addition to items specified in DelDot Standard Specification," provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

1.6 QUALITY ASSURANCE

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.
- B. Arc-Flash Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
  - 1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- C. Arc-Flash Study Specialist Qualifications: Professional engineer in charge of performing the study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

**PART 2 - PRODUCTS**

2.1 COMPUTER SOFTWARE DEVELOPERS

- A. Software Developers: Subject to compliance with requirements, provide software by one of the following:

1. ESA Inc.
  2. Operation Technology, Inc.
  3. Power Analytics, Corporation.
  4. SKM Systems Analysis, Inc.
- B. Comply with IEEE 1584 and NFPA 70E.
- C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

## 2.2 SHORT-CIRCUIT STUDY REPORT CONTENT

- A. Executive summary.
- B. Study descriptions, purpose, basis and scope.
- C. One-line diagram, showing the following:
1. Protective device designations and ampere ratings.
  2. Cable size and lengths.
  3. Transformer kilovolt ampere (kVA) and voltage ratings.
  4. Motor and generator designations and kVA ratings.
  5. Switchboard, motor-control center and panelboard designations.
- D. Study Input Data: As described in "Power System Data" Article.
- E. Short-Circuit Study Output:
1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    - a. Voltage.
    - b. Calculated symmetrical fault-current magnitude and angle.
    - c. Fault-point X/R ratio.
    - d. No AC Decrement (NACD) ratio.
    - e. Equivalent impedance.
    - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
    - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.
- F. Incident Energy and Flash Protection Boundary Calculations:
1. Arcing fault magnitude.
  2. Protective device clearing time.

3. Duration of arc.
  4. Arc-flash boundary.
  5. Working distance.
  6. Incident energy.
  7. Hazard risk category.
  8. Recommendations for arc-flash energy reduction.
- G. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

### 2.3 ARC-FLASH WARNING LABELS

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems." Produce a 3.5-by-5-inch thermal transfer label of high-adhesion polyester for each work location included in the analysis.
- B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:
1. Location designation.
  2. Nominal voltage.
  3. Flash protection boundary.
  4. Hazard risk category.
  5. Incident energy.
  6. Working distance.
  7. Engineering report number, revision number, and issue date.
- C. Labels shall be machine printed, with no field-applied markings.

## **PART 3 - EXECUTION**

### 3.1 EXAMINATION

- A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

### 3.2 SHORT-CIRCUIT STUDY

- A. Perform study following the general study procedures contained in IEEE 399.
- B. Calculate short-circuit currents according to IEEE 551.
- C. Base study on the device characteristics supplied by device manufacturer.
- D. The extent of the electrical power system to be studied is indicated on Drawings.

- E. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:
  - 1. To normal system low-voltage load buses where fault current is 10 kA or less.
  - 2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.
- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.
- G. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems.
- H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:
  - 1. Electric utility's supply termination point.
  - 2. Unit substation primary and secondary terminals.
  - 3. Low-voltage switchboard.
  - 4. Panelboards.
  - 5. Standby generators and automatic transfer switches.
  - 6. Branch circuit panelboards.

### 3.3 ARC-FLASH HAZARD ANALYSIS

- A. Comply with NFPA 70E and its Annex D for hazard analysis study.
- B. Use the short-circuit study output and the field-verified settings of the overcurrent devices.
- C. Calculate maximum and minimum contributions of fault-current size.
  - 1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
  - 2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.
- D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.
- E. Include medium- and low-voltage equipment locations, except 240-V ac and 208-V ac systems fed from transformers less than 125 kVA.

- F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.
- G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:
  - 1. Fault contribution from induction motors should not be considered beyond three to five 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 three per unit after 10 cycles).
- H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:
  - 1. When the circuit breaker is in a separate enclosure.
  - 2. When the line terminals of the circuit breaker are separate from the work location.
- I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

#### 3.4 POWER SYSTEM DATA

- A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.
  - 1. Verify completeness of data supplied on the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
  - 2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
  - 3. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers.
- B. Gather and tabulate the following input data to support coordination study. Comply with recommendations in IEEE 1584 and NFPA 70E as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.
  - 1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution

system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.

2. Obtain electrical power utility impedance at the service.
3. Power sources and ties.
4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in per cent, and phase shift.
5. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
6. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
7. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
8. Motor horsepower and NEMA MG 1 code letter designation.
9. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

### 3.5 LABELING

- A. Apply one arc-flash label for 600-V ac, 480-V ac, and applicable 208-V ac panelboards and disconnects and for each of the following locations:
  1. Service entrance rated transfer switch.
  2. Panelboards.
  3. Control panel.

### 3.6 APPLICATION OF WARNING LABELS

- A. Install the arc-fault warning labels under the direct supervision and control of the Arc-Flash Study Specialist.

### 3.7 DEMONSTRATION

- A. Engage the Arc-Flash Study Specialist to train Owner's maintenance personnel in the potential arc-flash hazards associated with working on energized equipment and the significance of the arc-flash warning labels.

**END OF SECTION**

## **SECTION 260923 - LIGHTING CONTROL DEVICES**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

**A. Section Includes:**

1. Time switches.
2. Photoelectric switches.
3. Indoor occupancy sensors.
4. Lighting contactors.

**B. Related Requirements:**

1. Section 262726 "Wiring Devices" for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.

#### **1.2 ACTION SUBMITTALS**

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

**B. Shop Drawings:** Show installation details for occupancy and light-level sensors.

1. Interconnection diagrams showing field-installed wiring.
2. Include diagrams for power, signal, and control wiring.

#### **1.3 INFORMATIONAL SUBMITTALS**

**A. Field quality-control reports.**

#### **1.4 CLOSEOUT SUBMITTALS**

**A. Operation and Maintenance Data:** For each type of lighting control device to include in emergency, operation, and maintenance manuals.

### **PART 2 - PRODUCTS**

#### **2.1 TIME SWITCHES**

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

1. Cooper Industries, Inc.
2. Intermatic, Inc.
3. Invensys Controls.
4. Leviton Manufacturing Co., Inc.
5. NSi Industries LLC; TORK Products.

6. Tyco Electronics; ALR Brand.
- B. Electronic Time Switches: Solid state, programmable, with alphanumeric display; complying with UL 917.
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  2. Contact Configuration: DPST.
  3. Contact Rating: 30-A inductive or resistive, 240-V ac.
  4. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels.
  5. Astronomic Time: Selected channels.
  6. Automatic daylight savings time changeover.
  7. Battery Backup: Not less than seven days reserve, to maintain schedules and time clock.

## 2.2 OUTDOOR PHOTOELECTRIC SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper Industries, Inc.
  2. Intermatic, Inc.
  3. NSi Industries LLC; TORK Products.
  4. Tyco Electronics; ALR Brand.
- B. Description: Solid state, with DPST dry contacts rated for 1800-VA tungsten or 1000-VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  2. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of the photocell to prevent fixed light sources from causing turn-off.
  3. Time Delay: Fifteen second minimum, to prevent false operation.
  4. Surge Protection: Metal-oxide varistor.
  5. Mounting: Twist lock complies with NEMA C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

## 2.3 INDOOR OCCUPANCY SENSORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper Industries, Inc.
  2. Hubbell Building Automation, Inc.

3. Leviton Manufacturing Co., Inc.
  4. Lithonia Lighting; Acuity Brands Lighting, Inc.
  5. Watt Stopper.
- B. General Requirements for Sensors: Wall- or ceiling-mounted, solid-state indoor occupancy sensors with a separate power pack.
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  2. Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
  3. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor is powered from the power pack.
  4. Power Pack: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
  5. 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.
    - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
  6. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
  7. Bypass Switch: Override the "on" function in case of sensor failure.
- C. Ultrasonic Type: Ceiling mounted; detect occupants in coverage area through pattern changes of reflected ultrasonic energy .
1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
  2. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet when mounted on a 10-foot- high ceiling in a corridor not wider than 14 feet.
- D. Dual-Technology Type: Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.
1. Sensitivity Adjustment: Separate for each sensing technology.
  2. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36

sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.

3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.
4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. when mounted on a 96-inch- high ceiling.

## 2.4 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

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

1. Cooper Industries, Inc.
2. Hubbell Building Automation, Inc.
3. Leviton Manufacturing Co., Inc.
4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. Lutron Electronics Co., Inc.
6. NSi Industries LLC; TORK Products.
7. Watt Stopper.

B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor, suitable for mounting in a single gang switchbox.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
3. Switch Rating: Not less than 800-VA fluorescent at 120 V, 1200-VA fluorescent at 277 V, and 800-W incandescent.

C. Wall-Switch Sensor Tag WS1:

1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 900 sq. ft..
2. Sensing Technology: Dual technology - PIR and ultrasonic.
3. Switch Type: SP, field selectable automatic "on," or manual "on" automatic "off."
4. Voltage: Dual voltage, 120 and 277 V; dual-technology type.
5. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
6. Concealed "off" time-delay selector at 30 seconds, and 5, 10, and 20 minutes.

## 2.5 LIGHTING CONTACTORS

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

1. Allen-Bradley/Rockwell Automation.

2. ASCO Power Technologies, LP.
  3. Eaton Corporation.
  4. General Electric Company; GE Consumer & Industrial - Electrical Distribution; Total Lighting Control.
- B. Description: Electrically operated and mechanically held, combination-type lighting contactors with nonfused disconnect, complying with NEMA ICS 2 and UL 508.
1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
  2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
  3. Enclosure: Comply with NEMA 250.
  4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.
- C. BAS Interface: Provide hardware interface to enable the BAS to monitor and control lighting contactors.
1. Monitoring: On-off status.
  2. Control: On-off operation.

## 2.6 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

## PART 3 - EXECUTION

### 3.1 SENSOR INSTALLATION

- A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

- B. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

### 3.2 CONTACTOR INSTALLATION

- A. Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

### 3.3 WIRING INSTALLATION

- A. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch.
- B. Wiring within Enclosures: Comply with NECA 1. 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, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

### 3.4 IDENTIFICATION

- A. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."
  - 1. Identify controlled circuits in lighting contactors.
  - 2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.
- B. Label time switches and contactors with a unique designation.

### 3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Contractor to evaluate lighting control devices and perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections:

1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
  2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Lighting control devices will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

### 3.6 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting sensors to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
  2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
  3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

### 3.7 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

**END OF SECTION**

## SECTION 262200 - LOW-VOLTAGE TRANSFORMERS

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:
  - 1. Distribution transformers.
  - 2. Harmonic Mitigation Transformers.

#### 1.2 ACTION SUBMITTALS

- A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 1. Wiring Diagrams: Power, signal, and control wiring.

#### 1.3 INFORMATIONAL SUBMITTALS

- A. Source quality-control test reports.

#### 1.4 CLOSEOUT SUBMITTALS

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

#### 1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain each transformer type through one source from a single manufacturer.
- B. 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.
- C. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

## 1.6 DELIVERY, STORAGE, AND HANDLING

- A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

## 1.7 COORDINATION

- A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
- B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

## **PART 2 - PRODUCTS**

### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Eaton Electrical Sector; Eaton Corporation; Cutler-Hammer Products.
  - 2. General Electric Company.
  - 3. Square D Co./Groupe Schneider NA; Schneider Electric.

### 2.2 GENERAL TRANSFORMER REQUIREMENTS

- A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
- B. Cores: Grain-oriented, non-aging silicon steel.
- C. Coils: Continuous windings without splices except for taps.
  - 1. Internal Coil Connections: Brazed or pressure type.
  - 2. Coil Material: Copper.

### 2.3 DISTRIBUTION TRANSFORMERS

- A. Comply with NEMA ST 20, and list and label as complying with UL 1561.
- B. Cores: One leg per phase.
- C. Enclosure: Ventilated, NEMA 250, Type 2.
  - 1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

- D. Transformer Enclosure Finish: Comply with NEMA 250.
  - 1. Finish Color: ANSI 61 gray.
- E. Taps for Transformers Smaller Than 3 kVA: One 5 percent tap above normal full capacity.
- F. Taps for Transformers 7.5 to 24 kVA: Two 5 percent taps below rated voltage.
- G. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.
- H. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 100 deg C rise above 40 deg C ambient temperature.
- I. Energy Efficiency for Transformers Rated 15 kVA and Larger:
  - 1. Complying with NEMA TP 1, Class 1 efficiency levels.
  - 2. Tested according to NEMA TP 2.
- J. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
  - 1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
  - 2. Indicate value of K-factor on transformer nameplate.
  - 3. Unit shall meet requirements of NEMA TP 1 when tested according to NEMA TP 2 with a K-factor equal to one.
- K. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
  - 1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
  - 2. Include special terminal for grounding the shield.
  - 3. Shield Effectiveness:
    - a. Capacitance between Primary and Secondary Windings: Not to exceed 33 picofarads over a frequency range of 20 Hz to 1 MHz.
    - b. Common-Mode Noise Attenuation: Minimum of minus 120 dBA at 0.5 to 1.5 kHz; minimum of minus 65 dBA at 1.5 to 100 kHz.
    - c. Normal-Mode Noise Attenuation: Minimum of minus 52 dBA at 1.5 to 10 kHz.
- L. Wall Brackets: Manufacturer's standard brackets.

- M. Low-Sound-Level Requirements: Maximum sound levels, when factory tested according to IEEE C57.12.91, as follows:

1. 9 kVA and Less: 40 dBA
2. 30 to 50 kVA: 45 dBA
3. 51 to 150 kVA: 50 dBA
4. 151 to 300 kVA: 55 dBA
5. 301 to 500 kVA: 60 dBA
6. 501 to 750 kVA: 62 dBA
7. 751 to 1000 kVA: 64 dBA

- N. Wiring: Copper.

## 2.4 IDENTIFICATION DEVICES

- A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

## 2.5 SOURCE QUALITY CONTROL

- A. Test and inspect transformers according to IEEE C57.12.91.
- B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.
- B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
- C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
- D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

- B. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Section 260529 "Hangers and Supports for Electrical Systems."

### 3.3 CONNECTIONS

- A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

### 3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B. Tests and Inspections:
  - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- C. Remove and replace units that do not pass tests or inspections and retest as specified above.
- D. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.
  - 1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
  - 2. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.
- E. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

### 3.5 ADJUSTING

- A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

- B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

- A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

**END OF SECTION**

## SECTION 262416 - PANELBOARDS

### PART 1 - GENERAL

#### 1.1 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.
3. Electronic-grade panelboards

#### 1.2 DEFINITIONS

A. TVSS: Transient voltage surge suppressor.

#### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
6. Include wiring diagrams for power, signal, and control wiring.
7. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

#### 1.4 INFORMATIONAL SUBMITTALS

A. Field Quality-Control Reports:

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.

- B. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

#### 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in DelDot Standard Specification, include the following:
  - 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
  - 2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

#### 1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Keys: Two spares for each type of panelboard cabinet lock.
  - 2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Two spares for each panelboard.

#### 1.7 QUALITY ASSURANCE

- A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NEMA PB 1.
- E. Comply with NFPA 70.

#### 1.8 DELIVERY, STORAGE, AND HANDLING

- A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
- B. Handle and prepare panelboards for installation according to NECA 407.

## 1.9 PROJECT CONDITIONS

### A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
  - a. Altitude: Not exceeding 6600 feet.

### B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Altitude not exceeding 6600 feet.

## 1.10 COORDINATION

- ### A.
- Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

## 1.11 WARRANTY

- ### A.
- Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

## PART 2 - PRODUCTS

### 2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

- ### A.
- Fabricate and test panelboards according to IEEE 344.
- ### B.
- Enclosures: Surface-mounted cabinets.
1. Rated for environmental conditions at installed location.
    - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
    - b. Outdoor and Wash Down Locations: NEMA 250, Type 4X, stainless steel.
    - c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
  2. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

3. Finishes:
    - a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
    - b. Back Boxes: Same finish as panels and trim.
    - c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.
  4. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.
- C. Incoming Mains Location: Top and bottom, as indicated.
- D. Phase, Neutral, and Ground Buses:
  1. Material: Hard-drawn copper, 98 percent conductivity.
  2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
  3. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.
- E. Conductor Connectors: Suitable for use with conductor material and sizes.
  1. Material: Hard-drawn copper, 98 percent conductivity.
  2. Main and Neutral Lugs: Mechanical type.
  3. Ground Lugs and Bus-Configured Terminators: Mechanical type.
  4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
  5. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
- F. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- G. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Series rating not acceptable.

## 2.2 DISTRIBUTION PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
  2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.

3. Square D; a brand of Schneider Electric.
  4. Siemens.
- B. Panelboards: NEMA PB 1; with factory-installed, integral TVSS; labeled by an NRTL for compliance with UL 67 after installing TVSS.
- C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
1. For doors more than 36 inches high, provide two latches, keyed alike.
- D. Mains: Circuit breaker or Lugs only, as indicated in schedules.
- E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
- F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

### 2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
  2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
  3. Square D; a brand of Schneider Electric.
  4. Siemens.
- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- D. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

### 2.4 ELECTRONIC-GRADE PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
  2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
  3. Square D; a brand of Schneider Electric.
  4. Siemens.

- B. Panelboards: NEMA PB 1; with factory-installed, integral TVSS; labeled by an NRTL for compliance with UL 67 after installing TVSS.
- C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
- D. Main Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.
- E. Branch Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.
- F. Buses:
  - 1. Copper phase and neutral buses; 200 percent capacity neutral bus and lugs.
  - 2. Copper equipment and ground buses.

## 2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
  - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
  - 3. Square D; a brand of Schneider Electric.
  - 4. Siemens.
- B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, 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. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
    - a. Instantaneous trip.
    - b. Long- and short-time pickup levels.
    - c. Long- and short-time time adjustments.
  - 3. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
    - a. Standard frame sizes, trip ratings, and number of poles.
    - b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.

- c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
- d. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Receive, inspect, handle, and store panelboards according to NECA 407.
- B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.2 INSTALLATION**

- A. Install panelboards and accessories according to NECA 407.
- B. Mount top of trim **90 inches** above finished floor unless otherwise indicated. Operating handle top mounted circuit breaker shall not be higher than 79 inches in on position.
- C. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- D. Install overcurrent protective devices and controllers not already factory installed.
  - 1. Set field-adjustable, circuit-breaker trip ranges.
- E. Install filler plates in unused spaces.
- F. Stub four **1-inch** empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four **1-inch** empty conduits into raised floor space or below slab not on grade.
- G. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.
- H. Comply with NECA 1.

### 3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 260553 "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

### 3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
  - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- D. Acceptance Testing Preparation:
  - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
  - 2. Test continuity of each circuit.
- E. Tests and Inspections:
  - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
  - 3. Perform the following infrared scan tests and inspections and prepare reports:

- a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
- b. Instruments and Equipment:
  - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
- F. Panelboards will be considered defective if they do not pass tests and inspections.
- G. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

### 3.5 ADJUSTING

- A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.
- B. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
  - 1. Measure as directed during period of normal system loading.
  - 2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
  - 3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
  - 4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

### 3.6 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

**END OF SECTION**

## SECTION 262726 - WIRING DEVICES

### PART 1 - GENERAL

#### 1.1 SUMMARY

A. Section Includes:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Twist locking receptacles.
3. Weather-resistant receptacles.
4. Cord and plug sets.
5. Snap switches.
6. Count down timer.

#### 1.2 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- D. RFI: Radio-frequency interference.
- E. TVSS: Transient voltage surge suppressor.
- F. UTP: Unshielded twisted pair.

#### 1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Receptacles for Owner-Furnished Equipment: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

## 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
  - 1. Cooper Wiring Devices; Division of Cooper Industries, Inc. (Cooper).
  - 2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
  - 3. Leviton Mfg. Company Inc. (Leviton).
  - 4. Pass & Seymour/Legrand (Pass & Seymour).
- B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

### 2.2 GENERAL WIRING-DEVICE REQUIREMENTS

- A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.
- C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:
  - 1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
  - 2. Devices shall comply with the requirements in this Section.

### 2.3 STRAIGHT-BLADE RECEPTACLES

- A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.
  - 1. Products: Subject to compliance with requirements, provide the following:
    - a. Cooper; 5351 (single), CR5362 (duplex).
    - b. Hubbell; HBL5351 (single), HBL5352 (duplex).
    - c. Leviton; 5891 (single), 5352 (duplex).
    - d. Pass & Seymour; 5361 (single), 5362 (duplex).

## 2.4 GFCI RECEPTACLES

- A. General Description:
  - 1. Straight blade, non-feed-through type.
  - 2. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.
  - 3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.
- B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:
  - 1. Products: Subject to compliance with requirements, provide the following:
    - a. Cooper; VGF20.
    - b. Hubbell; GFR5352L.
    - c. Pass & Seymour; 2095.
    - d. Leviton; 7590.

## 2.5 HAZARDOUS (CLASSIFIED) LOCATION RECEPTACLES

- A. Available Wiring Devices for Hazardous (Classified) Locations: Comply with NEMA FB 11 and UL 1010.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    - a. Cooper Crouse-Hinds.
    - b. EGS/Appleton Electric.
    - c. Killark; Division of Hubbell Inc.

## 2.6 TWIST-LOCKING RECEPTACLES

- A. Single Convenience Receptacles, 125V: Comply with NEMA WD1, NEMA WD 6 Configuration I and UL 498 as indicated on Drawings.

## 2.7 CORD AND PLUG SETS

- A. Description:
  - 1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
  - 2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.
  - 3. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

## 2.8 TOGGLE SWITCHES

- A. Comply with NEMA WD 1, UL 20, and FS W-S-896.
- B. Switches, 120/277 V, 20 A:
  - 1. Products: Subject to compliance with requirements, provide the following:
    - a. Single Pole:
      - 1) Cooper; AH1221.
      - 2) Hubbell; HBL1221.
      - 3) Leviton; 1221-2.
      - 4) Pass & Seymour; CSB20AC1.
    - b. Two Pole:
      - 1) Cooper; AH1222.
      - 2) Hubbell; HBL1222.
      - 3) Leviton; 1222-2.
      - 4) Pass & Seymour; CSB20AC2.
    - c. Three Way:
      - 1) Cooper; AH1223.
      - 2) Hubbell; HBL1223.
      - 3) Leviton; 1223-2.
      - 4) Pass & Seymour; CSB20AC3.
    - d. Four Way:
      - 1) Cooper; AH1224.
      - 2) Hubbell; HBL1224.
      - 3) Leviton; 1224-2.
      - 4) Pass & Seymour; CSB20AC4.

## 2.9 COUNT DOWN TIMER

- A. Comply with NEMA WD1, UL20.
- B. Switches, 120/277V.
  - 1. Single pole with variable 60 minute time range.

## 2.10 WALL PLATES

- A. Single and combination types shall match corresponding wiring devices.
  - 1. Plate-Securing Screws: Metal with head color to match plate finish.

2. Material for Finished Spaces: Steel with white baked enamel, suitable for field painting.
  3. Material for Unfinished Spaces: Galvanized steel.
  4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.
- B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

## 2.11 FINISHES

- A. Device Color:
1. Wiring Devices Connected to Normal Power System: As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.
- B. Wall Plate Color: For plastic covers, match device color.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.
- B. Coordination with Other Trades:
1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
  2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
  3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
  4. Install wiring devices after all wall preparation, including painting, is complete.
- C. Conductors:
1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
  2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
  3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.

4. Existing Conductors:

- a. Cut back and pigtail, or replace all damaged conductors.
- b. Straighten conductors that remain and remove corrosion and foreign matter.
- c. Pigtailling existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

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

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.

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

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

H. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES

- A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION

- A. Comply with Section 260553 "Identification for Electrical Systems."
- B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
  - 1. Test Instruments: Use instruments that comply with UL 1436.
  - 2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
- B. Tests for Convenience Receptacles:
  - 1. Line Voltage: Acceptable range is 105 to 132 V.
  - 2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
  - 3. Ground Impedance: Values of up to 2 ohms are acceptable.
  - 4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
  - 5. Using the test plug, verify that the device and its outlet box are securely mounted.
  - 6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.
- C. Wiring device will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

**END OF SECTION**

## SECTION 262816 - ENCLOSED SWITCHES

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
  - 1. Nonfusible switches.
  - 2. Enclosures.

#### 1.2 DEFINITIONS

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

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
  - 1. Enclosure types and details for types other than NEMA 250, Type 1.
  - 2. Current and voltage ratings.
  - 3. Short-circuit current ratings (interrupting and withstand, as appropriate).
  - 4. Include evidence of NRTL listing for series rating of installed devices.
  - 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
- B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
  - 1. Wiring Diagrams: For power, signal, and control wiring.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Field quality-control reports.
  - 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.

- C. Manufacturer's field service report.

#### 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in DelDot Standard Specification, include the following:
  - 1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
  - 2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Submit on translucent log-log graph paper.

#### 1.6 QUALITY ASSURANCE

- A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NFPA 70.

#### 1.7 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
  - 1. Ambient Temperature: Not less than **minus 22 deg F** and not exceeding **104 deg F**.

#### 1.8 COORDINATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

## **PART 2 - PRODUCTS**

### **2.1 NONFUSIBLE SWITCHES**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
  - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
  - 3. Siemens Energy & Automation, Inc.
  - 4. Square D; a brand of Schneider Electric.
- B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- C. Accessories:
  - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
  - 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
  - 3. Lugs: Compression type, suitable for number, size, and conductor material.

### **2.2 ENCLOSURES**

- A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
  - 1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
  - 2. Outdoor Locations: NEMA 250, Type 4X, stainless steel.
  - 3. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
  - 4. Indoor Locations (Maintenance Bays and Shops) Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Install individual wall-mounted switches with tops at uniform height unless otherwise indicated.
- B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- C. Install fuses in fusible devices.
- D. Comply with NECA 1.

### 3.3 IDENTIFICATION

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems."
  - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
  - 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

### 3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Perform tests and inspections.
- B. Acceptance Testing Preparation:
  - 1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
  - 2. Test continuity of each circuit.
- C. Tests and Inspections:
  - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
  - 3. Perform the following infrared scan tests and inspections and prepare reports:
    - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.

- b. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  - 4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
  - D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
  - E. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- 3.5 ADJUSTING
- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

**END OF SECTION**

## SECTION 262913 - ENCLOSED CONTROLLERS

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section includes the following enclosed controllers rated 600 V and less:
  - 1. Full-voltage manual.
  - 2. Full-voltage magnetic.
  - 3. Multispeed.

#### 1.2 DEFINITIONS

- A. CPT: Control power transformer.
- B. MCCB: Molded-case circuit breaker.
- C. MCP: Motor circuit protector.
- D. N.C.: Normally closed.
- E. N.O.: Normally open.
- F. OCPD: Overcurrent protective device.
- G. SCR: Silicon-controlled rectifier.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of enclosed controller. Include manufacturer's technical data on features, performance, electrical characteristics, ratings, and enclosure types and finishes.
- B. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.
  - 1. Show tabulations of the following:
    - a. Each installed unit's type and details.
    - b. Factory-installed devices.
    - c. Nameplate legends.
    - d. Short-circuit current rating of integrated unit.
    - e. Listed and labeled for integrated short-circuit current (withstand) rating of OCPDs in combination controllers by an NRTL acceptable to authorities having jurisdiction.

- f. Features, characteristics, ratings, and factory settings of individual OCPDs in combination controllers.

2. Wiring Diagrams: For power, signal, and control wiring.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Field quality-control reports.
- C. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.
- D. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.

#### 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in DelDot Standard Specification, include the following:
  1. Routine maintenance requirements for enclosed controllers and installed components.
  2. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
  3. Manufacturer's written instructions for setting field-adjustable overload relays.
  4. Manufacturer's written instructions for testing, adjusting, and reprogramming reduced-voltage solid-state controllers.

#### 1.6 MATERIALS MAINTENANCE SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  1. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
  2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
  3. Indicating Lights: Two of each type and color installed.
  4. Auxiliary Contacts: Furnish one spare for each size and type of magnetic controller installed.
  5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

## 1.7 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.

## 1.8 DELIVERY, STORAGE, AND HANDLING

- A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- B. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install temporary electric heating, with at least 250 W per controller.

## 1.9 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
  - 1. Ambient Temperature: Not less than **minus 22 deg F** and not exceeding **104 deg F**.
  - 2. Altitude: Not exceeding **6600 feet**.

## 1.10 COORDINATION

- A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
- C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

## **PART 2 - PRODUCTS**

### 2.1 FULL-VOLTAGE CONTROLLERS

- A. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.

- B. Motor-Starting Switches: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
    - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
    - c. Rockwell Automation, Inc.; Allen-Bradley brand.
    - d. Siemens Energy & Automation, Inc.
    - e. Square D; a brand of Schneider Electric.
  2. Configuration: Nonreversing.
  3. Surface mounting.
  4. Red pilot light.
- C. Fractional Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
    - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
    - c. Rockwell Automation, Inc.; Allen-Bradley brand.
    - d. Siemens Energy & Automation, Inc.
    - e. Square D; a brand of Schneider Electric.
  2. Configuration: Nonreversing.
  3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button electronic.
  4. Surface mounting.
  5. Red pilot light.
- D. Integral Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
    - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
    - c. Rockwell Automation, Inc.; Allen-Bradley brand.
    - d. Siemens Energy & Automation, Inc.

- e. Square D; a brand of Schneider Electric.
  - 2. Configuration: Nonreversing.
  - 3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters and sensors in each phase, matched to nameplate full-load current of actual protected motor and having appropriate adjustment for duty cycle; external reset push button electronic.
  - 4. Surface mounting.
  - 5. Red pilot light.
  - 6. N.O., N.C. auxiliary contact.
- E. Magnetic Controllers: Full voltage, across the line, electrically held.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
    - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
    - c. Rockwell Automation, Inc.; Allen-Bradley brand.
    - d. Siemens Energy & Automation, Inc.
    - e. Square D; a brand of Schneider Electric.
  - 2. Configuration: Nonreversing.
  - 3. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.
    - a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
  - 4. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
  - 5. Control Circuits: Obtained from integral CPT, with primary and secondary fuses, with of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
    - a. CPT Spare Capacity: 100 VA.
  - 6. Solid-State Overload Relay:
    - a. Switch or dial selectable for motor running overload protection.
    - b. Sensors in each phase.
    - c. Class 20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.

- d. Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
  - e. Analog communication module.
  - 7. N.C., N.O., isolated overload alarm contact.
  - 8. External overload reset push button.
- F. Combination Magnetic Controller: Factory-assembled combination of magnetic controller, OCPD, and disconnecting means.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
    - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
    - c. Rockwell Automation, Inc.; Allen-Bradley brand.
    - d. Siemens Energy & Automation, Inc.
    - e. Square D; a brand of Schneider Electric.
  - 2. Fusible Disconnecting Means:
    - a. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J fuses.
    - b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
  - 3. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
  - 4. Nonfusible Disconnecting Means:
    - a. NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
    - b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
    - c. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.

## 2.2 ACCESSORIES

- A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.
- 1. Push Buttons, Pilot Lights, and Selector Switches: Heavy-duty, oiltight type.
    - a. Push Buttons: Covered types.
    - b. Pilot Lights: LED types; colors as indicated; push to test.
    - c. Selector Switches: Rotary type.

2. Elapsed Time Meters: Heavy duty with digital readout in hours; resettable.
- B. Reversible N.C./N.O. auxiliary contact(s).

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Examine areas and surfaces to receive enclosed controllers, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.
- B. Examine enclosed controllers before installation. Reject enclosed controllers that are wet, moisture damaged, or mold damaged.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.2 INSTALLATION**

- A. **Wall-Mounted Controllers:** Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."
- B. **Floor-Mounted Controllers:** Install enclosed controllers on **4-inch** nominal-thickness concrete base. Comply with requirements for concrete base specified in DelDot Standard Specification.
  1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch** centers around the full perimeter of concrete base.
  2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  4. Install anchor bolts to elevations required for proper attachment to supported equipment.
- C. **Temporary Lifting Provisions:** Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- D. Install fuses in control circuits if not factory installed.
- E. Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

- F. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
- G. Comply with NECA 1.

### 3.3 IDENTIFICATION

- A. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
  - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
  - 2. Label each enclosure with engraved nameplate.
  - 3. Label each enclosure-mounted control and pilot device.

### 3.4 CONTROL WIRING INSTALLATION

- A. Install wiring between enclosed controllers and remote devices.
- B. Bundle, train, and support wiring in enclosures.
- C. Connect selector switches and other automatic-control selection devices where applicable.
  - 1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
  - 2. Connect selector switches with enclosed-controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

### 3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
  - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- D. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

E. Tests and Inspections:

1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at controller locations are within plus or minus 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Owner before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:
  - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each multi-pole enclosed controller. Remove front panels so joints and connections are accessible to portable scanner.
  - b. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. Enclosed controllers will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports including a certified report that identifies enclosed controllers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

### 3.6 ADJUSTING

A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

3.7 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.
- B. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.8 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers.

**END OF SECTION**

## SECTION 263213 - ENGINE GENERATORS

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section includes packaged engine-generator sets for standby power supply with the following features:
  - 1. Natural-gas with LP backup engine.
  - 2. Unit-mounted cooling system.
  - 3. Unit-mounted and remote-mounted control and monitoring.
  - 4. Performance requirements for sensitive loads.
  - 5. Fuel system.
  - 6. Outdoor enclosure.
- B. Related Requirements:
  - 1. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

#### 1.2 DEFINITIONS

- A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.
- B. EPS: Emergency power supply.
- C. EPSS: Emergency power supply system.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
  - 2. Include thermal damage curve for generator.
  - 3. Include time-current characteristic curves for generator protective device.
  - 4. Include fuel consumption in cubic feet per hour at 0.8 power factor at 0.5, 0.75 and 1.0 times generator capacity.
  - 5. Include generator efficiency at 0.8 power factor at 0.5, 0.75 and 1.0 times generator capacity.
  - 6. Include air flow requirements for cooling and combustion air in cfm at 0.8 power factor, with air supply temperature of 95, 80, 70, and 50 deg F.

Provide drawings showing requirements and limitations for location of air intake and exhausts.

7. Include generator characteristics, including, but not limited to kw rating, efficiency, reactances, and short-circuit current capability.

B. Shop Drawings:

1. Include plans and elevations for engine-generator set and other components specified. Indicate access requirements affected by height of subbase fuel tank.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer, manufacturer, and testing agency.

B. Source quality-control reports, including, but not limited to the following:

1. Certified summary of prototype-unit test report.
2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
5. Report of sound generation.
6. Report of exhaust emissions showing compliance with applicable regulations.
7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

C. Field quality-control reports.

D. Warranty: For special warranty.

## 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals.
  - 1. In addition to items specified in DelDot Standard Specification, include the following:
    - a. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
    - b. Operating instructions laminated and mounted adjacent to generator location.
    - c. Training plan.

## 1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Fuses: One for every 10 of each type and rating but no fewer than one of each.
  - 2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
  - 3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
  - 4. Tools: Each tool listed by part number in operations and maintenance manual.

## 1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved by manufacturer.
- B. Testing Agency Qualifications: Member company of NETA or an NRTL.
  - 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

## 1.8 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period: Five years from date of Substantial Completion.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.

### **2.2 PERFORMANCE REQUIREMENTS**

- A. ASME Compliance: Comply with ASME B15.1.
- B. NFPA Compliance:
  - 1. Comply with NFPA 37.
  - 2. Comply with NFPA 70.
  - 3. Comply with NFPA 110 requirements for Level 2 emergency power supply system.
- C. UL Compliance: Comply with UL 2200.
- D. Engine Exhaust Emissions: Engine shall be EPA compliant to the 2009 NSPS emission standards for natural gas gen sets.
- E. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.
- F. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
  - 1. Ambient Temperature: Minus 15 to plus 40 deg C.
  - 2. Relative Humidity: Zero to 95 percent.
  - 3. Altitude: Sea level to 1000 feet (300 m).
- G. Unusual Service Conditions: Engine-generator equipment and installation are required to operate under the following conditions:
  - 1. High salt-dust content in the air due to sea-spray evaporation.

### **2.3 ASSEMBLY DESCRIPTION**

- A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.

- C. Induction Method: Naturally aspirated.
- D. Governor: Adjustable isochronous, with speed sensing.
- E. Emissions: Provide a certified engine per the EPA's non-road source emissions standard 40 CFR89. The appropriate tier level shall apply based upon the Hp of the engine.
- F. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.
  - 1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.
- G. Capacities and Characteristics:
  - 1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries.
  - 2. Output Connections: Three-phase, four wire.
  - 3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.
- H. Generator-Set Performance:
  - 1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
  - 2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
  - 3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
  - 4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
  - 5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
  - 6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
  - 7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of

rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.

8. Start Time: Comply with NFPA 110, Type 10, system requirements.

I. Generator-Set Performance for Sensitive Loads:

1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.
  - a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.
7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
  - a. Provide permanent magnet excitation for power source to voltage regulator.
10. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.4 ENGINE

- A. Fuel: Natural gas.
- B. Rated Engine Speed: 1800 rpm.

- C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm (11.4 m/s).
- D. Lubrication System: The following items are mounted on engine or skid:
1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
  2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
  3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
- E. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 2 equipment for heater capacity.
- F. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.
1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
  2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
  3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
  4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
  5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
    - a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and noncollapsible under vacuum.
    - b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
- G. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
1. Minimum sound attenuation of 25 dB at 500 Hz.
  2. Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 78 dBA or less.

- H. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
- I. Starting System: 12 or 24-V electric, with negative ground.
  - 1. Components: Sized so they are not damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" Article.
  - 2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
  - 3. Cranking Cycle: As required by NFPA 110 for system level specified.
  - 4. Battery: Lead acid or Nicad, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least three times without recharging.
  - 5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
  - 6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
  - 7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
  - 8. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35 A minimum continuous rating.
  - 9. Battery Charger: Current-limiting, automatic-equalizing and float-charging type designed for lead-acid or Nicad batteries. Unit shall comply with UL 1236 and include the following features:
    - a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
    - b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from **minus 40 deg F (minus 40 deg C)** to **140 deg F (plus 60 deg C)** to prevent overcharging at high temperatures and undercharging at low temperatures.
    - c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
    - d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.

- e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
- f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

## 2.5 GASEOUS FUEL SYSTEM

- A. Natural-Gas Piping: Comply with requirements in Section 231123 "Facility Natural-Gas Piping."
- B. Gas Train: Comply with NFPA 37.
- C. Engine Fuel System:
  - 1. Natural-Gas, Vapor-Withdrawal System:
    - a. Carburetor.
    - b. Fuel-Shutoff Solenoid Valves: NRTL-listed, normally closed, safety shutoff valves; one for each fuel source.
    - c. Fuel Filters: One for each fuel type.
    - d. Manual Fuel Shutoff Valves: One for each fuel type.
    - e. Flexible Fuel Connectors: Minimum one for each fuel connection.

## 2.6 CONTROL AND MONITORING

- A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms.
- B. Provide minimum run time control set for 30 minutes with override only by operation of a remote emergency-stop switch.
- C. Comply with UL 508A.
- D. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration. Panel shall be powered from the engine-generator set battery.

- E. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel. Panel shall be powered from the engine-generator set battery.
  
- F. Indicating Devices : As required by NFPA 110 for Level 2 system, including the following:
  - 1. AC voltmeter.
  - 2. AC ammeter.
  - 3. AC frequency meter.
  - 4. EPS supplying load indicator.
  - 5. Ammeter and voltmeter phase-selector switches.
  - 6. DC voltmeter (alternator battery charging).
  - 7. Engine-coolant temperature gage.
  - 8. Engine lubricating-oil pressure gage.
  - 9. Running-time meter.
  - 10. Current and Potential Transformers: Instrument accuracy class.
  
- G. Protective Devices and Controls in Local Control Panel: Shutdown devices and common visual alarm indication as required by NFPA 110 for Level 2 system, including the following:
  - 1. Start-stop switch.
  - 2. Overcrank shutdown device.
  - 3. Overspeed shutdown device.
  - 4. Coolant high-temperature shutdown device.
  - 5. Coolant low-level shutdown device.
  - 6. Low lube oil pressure shutdown device.
  - 7. Air shutdown damper shutdown device when used.
  - 8. Overcrank alarm.
  - 9. Overspeed alarm.
  - 10. Coolant high-temperature alarm.
  - 11. Coolant low-temperature alarm.
  - 12. Coolant low-level alarm.
  - 13. Low lube oil pressure alarm.
  - 14. Air shutdown damper alarm when used.
  - 15. Lamp test.
  - 16. Contacts for local and remote common alarm.
  - 17. Coolant high-temperature prealarm.
  - 18. Generator-voltage adjusting rheostat.
  - 19. Main fuel.
    - a. Low natural gas pressure alarm.
  - 20. Run-Off-Auto switch.
  - 21. Control switch not in automatic position alarm.

22. Low cranking voltage alarm.
  23. Battery-charger malfunction alarm.
  24. Battery low-voltage alarm.
  25. Battery high-voltage alarm.
  26. Generator overcurrent protective device not closed alarm.
- H. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.
- I. Remote Alarm Annunciator: An LED labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.
1. Overcrank alarm.
  2. Coolant low-temperature alarm.
  3. High engine temperature prealarm.
  4. High engine temperature alarm.
  5. Low lube oil pressure alarm.
  6. Overspeed alarm.
  7. Low natural gas pressure alarm.
  8. Low coolant level alarm.
  9. Low cranking voltage alarm.
  10. Contacts for local and remote common alarm.
  11. Audible-alarm silencing switch.
  12. Air shutdown damper when used.
  13. Run-Off-Auto switch.
  14. Control switch not in automatic position alarm.
  15. Low cranking voltage alarm.
  16. Generator overcurrent protective device not closed.
- J. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.
- K. Remote Emergency-Stop Switch: Flush; wall mounted on exterior of generator enclosure, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation in a NEMA 4X enclosure.

## 2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION

- A. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.
  - 1. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.
- B. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.
  - 1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
  - 2. Trip Settings: Selected to coordinate with generator thermal damage curve.
  - 3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
  - 4. Mounting: Adjacent to or integrated with control and monitoring panel.
- C. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground fault.
  - 1. Indicate ground fault with other generator-set alarm indications.

## 2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

- A. Comply with NEMA MG 1.
- B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
- C. Electrical Insulation: Class H.
- D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. Provide 12 lead alternator.
- E. Range: Provide broad range of output voltage by adjusting the excitation level.
- F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
- G. Enclosure: Dripproof.
- H. Instrument Transformers: Mounted within generator enclosure.
- I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified and as required by NFPA 110.

1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
  2. Maintain voltage within 30 percent on one step, full load.
  3. Provide anti-hunt provision to stabilize voltage.
  4. Maintain frequency within 15 percent and stabilize at rated frequency within 5 seconds.
- J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
- K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
- L. Subtransient Reactance: 12 percent, maximum.

## 2.9 OUTDOOR GENERATOR-SET ENCLOSURE

- A. Description: Vandal-resistant, sound-attenuating, weatherproof steel housing, wind resistant up to 140 mph (160 km/h). Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.
- B. Description: Prefabricated or pre-engineered galvanized-steel-clad, integral structural-steel-framed, walk-in enclosure, erected on concrete foundation.
1. Space Heater: Thermostatically controlled and sized to prevent condensation.
  2. Lighting: Provide weather resistant fluorescent lighting with 30 footcandles ((330 LUX)) average maintained.
  3. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine-generator-set components.
  4. Muffler Location: Within enclosure.
- C. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.
1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
- D. Interior Lights with Switch: Factory-wired, vapor-proof fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.

1. AC lighting system and connection point for operation when remote source is available.
- E. Convenience Outlets: Factory wired, GFCI. Arrange for external electrical connection.

## 2.10 MOTORS

- A. Description: NEMA MG 1, Design B, medium induction random-wound, squirrel cage motor.
- B. Efficiency: Energy efficient, as defined in NEMA MG 1.
- C. Service Factor: 1.15.
- D. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- E. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- F. Temperature Rise: Match insulation rating.
- G. Code Letter Designation:
  1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
- H. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.
- I. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

## 2.11 VIBRATION ISOLATION DEVICES

- A. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.
  1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to ~~1/4-inch-~~ (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
  2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
  3. Minimum Additional Travel: 50 percent of required deflection at rated load.
  4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
  6. Minimum Deflection: 1 inch (25 mm).
- B. Comply with requirements in Section 232116 "Hydronic Piping Specialties" for vibration isolation and flexible connectors materials for steel piping.
  - C. Comply with requirements in Section 233113 "Metal Ducts" for vibration isolation and flexible connector materials for exhaust shroud and ductwork.
  - D. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

## 2.12 FINISHES

- A. Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

## 2.13 SOURCE QUALITY CONTROL

- A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
  1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.
- B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:
  1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
  2. Test generator, exciter, and voltage regulator as a unit.
  3. Full load run.
  4. Maximum power.
  5. Voltage regulation.
  6. Transient and steady-state governing.
  7. Single-step load pickup.
  8. Safety shutdown.
  9. Report factory test results within 10 days of completion of test.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.
- B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTALLATION**

- A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.
- B. Equipment Mounting:
  - 1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
  - 2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
  - 3. Coordinate size and location of roof curbs, equipment supports, and roof penetrations for remote radiators. These items are specified in Section 077200 "Roof Accessories."
- C. Install packaged engine-generator to provide access, without removing connections or accessories, for periodic maintenance.
- D. Install packaged engine-generator with restrained spring isolators having a minimum deflection of **1 inch (25 mm)** on **4-inch- (100-mm-)** high concrete base. Secure enclosure to anchor bolts installed in concrete bases. Concrete base construction is specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- E. Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet.
  - 1. Install flexible connectors and steel piping materials according to requirements in Section 232116 Hydronic Piping Specialties."
  - 2. Insulate muffler/silencer and exhaust system components according to requirements in Section 230719 "HVAC Piping Insulation."

3. Install isolating thimbles where exhaust piping penetrates combustible surfaces with a minimum of **9 inches (225 mm)** clearance from combustibles.
- F. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints.
- G. Installation requirements for piping materials and flexible connectors are specified in Section 232116 "Hydronic Piping Specialties." Copper and galvanized steel shall not be used in the fuel-oil piping system.
- H. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

### 3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.
- B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine-generator to allow service and maintenance.
- C. Connect cooling-system water piping to engine-generator set and heat exchanger with flexible connectors.
- D. Connect engine exhaust pipe to engine with flexible connector.
- E. Connect fuel piping to engines with a gate valve and union and flexible connector.
  1. Natural-gas piping, valves, and specialties for gas distribution are specified in Section 231123 "Facility Natural-Gas Piping."
  2. Install manual shutoff valve in a remote location to isolate natural-gas supply to the generator enclosure.
  3. Vent gas pressure regulators outside building a minimum of **60 inches (1500 mm)** from building openings.
- F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one 90 degree bend in flexible conduit routed to the generator set from a stationary element.
- H. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

### 3.4 IDENTIFICATION

- A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."
- B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

### 3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
  - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections.
- D. Tests and Inspections:
  - 1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in the first two subparagraphs as specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
    - a. Visual and Mechanical Inspection
      - 1) Compare equipment nameplate data with drawings and specifications.
      - 2) Inspect physical and mechanical condition.
      - 3) Inspect anchorage, alignment, and grounding.
      - 4) Verify the unit is clean.
    - b. Electrical and Mechanical Tests
      - 1) Perform insulation-resistance tests in accordance with IEEE 43.
        - a) Machines larger than 200 horsepower (150 kilowatts). Test duration shall be 10 minutes. Calculate polarization index.

- b) Machines 200 horsepower (150 kilowatts) or less. Test duration shall be one minute. Calculate the dielectric-absorption ratio.
    - 2) Test protective relay devices.
    - 3) Verify phase rotation, phasing, and synchronized operation as required by the application.
    - 4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
    - 5) Conduct performance test in accordance with NFPA 110.
    - 6) Verify correct functioning of the governor and regulator.
  2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
  3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
    - a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
    - b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
    - c. Verify acceptance of charge for each element of the battery after discharge.
    - d. Verify that measurements are within manufacturer's specifications.
  4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
  5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
  6. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
  7. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 percent and 100 percent of rated linear load. Verify that harmonic content is within specified limits.
  8. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations 25 feet (7.6 m) from edge of the generator enclosure, and compare measured levels with required values.

E. Coordinate tests with tests for transfer switches and run them concurrently.

- F. Test instruments shall have been calibrated within the last 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.
- G. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.
- H. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.
- I. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- J. Remove and replace malfunctioning units and reinspect as specified above.
- K. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
- L. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- M. Infrared Scanning: After Substantial Completion, but not more than 60 days after final acceptance, perform an infrared scan of each power wiring termination and each bus connection while running with maximum load. Remove all access panels so terminations and connections are accessible to portable scanner.
  - 1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  - 2. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

### 3.6 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

**END OF SECTION**

## SECTION 263600 - TRANSFER SWITCHES

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section includes transfer switches rated 600 V and less, including the following:
  - 1. Automatic transfer switches.
  - 2. Bypass/isolation switches.

#### 1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
  - 1. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.

#### 1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in DelDot Standard Specification, include the following:
  - 1. Features and operating sequences, both automatic and manual.
  - 2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

#### 1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.
- B. Source Limitations: Obtain automatic transfer switches and bypass/isolation switches through one source from a single manufacturer.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NEMA ICS 1.

- E. Comply with NFPA 70.
- F. Comply with NFPA 99.
- G. Comply with NFPA 110.
- H. Comply with UL 1008 unless requirements of these Specifications are stricter.

#### 1.5 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 033000 "Cast-in-Place Concrete."

### **PART 2 - PRODUCTS**

#### 2.1 MANUFACTURED UNITS

- A. Contactor Transfer Switches:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one the following:
    - a. Emerson; ASCO Power Technologies, LP.
    - b. GE Zenith Controls.
    - c. Russelectric, Inc.

#### 2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

- A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
- B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
  - 1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
- C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
- D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

- E. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.
- F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
  - 1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
  - 2. Switch Action: Double throw; mechanically held in both directions.
  - 3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.
- G. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Section 260553 "Identification for Electrical Systems."
  - 1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
  - 2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
  - 3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
- H. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

### 2.3 AUTOMATIC TRANSFER SWITCH (SERVICE ENTRANCE RATED)

- A. Comply with Level 2 equipment according to NFPA 110.
- B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.
- C. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.
- D. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.

E. Automatic Transfer-Switch Features:

1. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
4. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
  - a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
  - b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
12. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory

settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

- a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
- b. Push-button programming control with digital display of settings.
- c. Integral battery operation of time switch when normal control power is not available.

## 2.4 BYPASS/ISOLATION SWITCHES

- A. Comply with requirements for Level 2 equipment according to NFPA 110.
- B. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:
  1. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. While isolated, interlocks prevent transfer-switch operation, except for testing or maintenance.
  2. Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations.
  3. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
  4. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
  5. Operability: Constructed so load bypass and transfer-switch isolation can be performed by 1 person in no more than 2 operations in 15 seconds or less.
  6. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
  7. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.
- C. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

## 2.5 CIRCUIT BREAKERS

- A. Provide molded case, circuit breakers with solid state trip as indicated on drawings. Long-time, short-time, and instantaneous trip shall be provided.

## 2.6 SOURCE QUALITY CONTROL

- A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Floor-Mounting Switch: Anchor to floor by bolting.
  - 1. Concrete Bases: 4 inches high, reinforced, with chamfered edges. Extend base no more than 4 inches in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Section 260529 "Hangers and Supports for Electrical Systems."
- B. Identify components according to Section 260553 "Identification for Electrical Systems."
- C. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

### 3.2 CONNECTIONS

- A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

### 3.3 FIELD QUALITY CONTROL

- A. Testing Agency: Perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
  2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  3. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
    - a. Check for electrical continuity of circuits and for short circuits.
    - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
    - c. Verify that manual transfer warnings are properly placed.
    - d. Perform manual transfer operation.
  4. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
    - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
    - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
    - c. Verify time-delay settings.
    - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
    - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
    - f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
    - g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
  5. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
    - a. Verify grounding connections and locations and ratings of sensors.
- D. Testing Agency's Tests and Inspections:
1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
  2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

3. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
  - a. Check for electrical continuity of circuits and for short circuits.
  - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
  - c. Verify that manual transfer warnings are properly placed.
  - d. Perform manual transfer operation.
4. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
  - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
  - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
  - c. Verify time-delay settings.
  - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
  - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
  - f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
  - g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
5. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
  - a. Verify grounding connections and locations and ratings of sensors.
- E. Coordinate tests with tests of generator and run them concurrently.
- F. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- G. Remove and replace malfunctioning units and retest as specified above.
- H. Prepare test and inspection reports.
- I. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
2. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.
- B. Coordinate this training with that for generator equipment.

**END OF SECTION**

**SECTION 264313 - SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL  
POWER CIRCUITS**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. Section includes field-mounted SPDs for low-voltage (120 to 600 V) power distribution and control equipment.
- B. Related Requirements:
  - 1. Section 262416 "Panelboards" for factory-installed SPDs.

**1.2 DEFINITIONS**

- A. Inominal: Nominal discharge current.
- B. MCOV: Maximum continuous operating voltage.
- C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.
- D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.
- E. OCPD: Overcurrent protective device.
- F. SCCR: Short-circuit current rating.
- G. SPD: Surge protective device.
- H. VPR: Voltage protection rating.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
  - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
  - 2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.

**1.4 INFORMATIONAL SUBMITTALS**

- A. Field quality-control reports.

B. Sample Warranty: For manufacturer's special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For SPDs to include in maintenance manuals.

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to replace or replace SPDs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

**PART 2 - PRODUCTS**

2.1 GENERAL SPD REQUIREMENTS

A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. Comply with UL 1449.

D. MCOV of the SPD shall be the nominal system voltage.

2.2 SERVICE ENTRANCE SUPPRESSOR DISTRIBUTION PANEL "MDPN"

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

1. Eaton Corporation.
2. GE Zenith Controls.
3. Schneider Electric Industries SAS.
4. Siemens Industry, Inc.

B. SPDs: Comply with UL 1449.

C. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449.

1. SPDs with the following features and accessories:
  - a. Integral disconnect switch.
  - b. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
  - c. Indicator light display for protection status.
  - d. Surge counter.

- D. Comply with UL 1283.
- E. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 200 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
- F. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V, three-phase, four-wire circuits shall not exceed the following:
  - 1. Line to Neutral: 1200 V for 480Y/277 V.
  - 2. Line to Ground: 1200 V for 480Y/277 V.
  - 3. Line to Line: 2000 V for 480Y/277 V.
- G. SCCR: Equal or exceed 200 kA.
- H. Inominal Rating: 20 kA.

### 2.3 PANEL SUPPRESSORS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - 1. Eaton Corporation.
  - 2. GE Zenith Controls.
  - 3. Schneider Electric Industries SAS.
  - 4. Siemens Industry, Inc.
- B. SPDs: Comply with UL 1449.
  - 1. Include LED indicator lights for power and protection status.
  - 2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
- C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 100 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
- D. Comply with UL 1283.
- E. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V, 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:
  - 1. Line to Neutral: 1200 V for 480Y/277 V, 700 V for 208Y/120 V.
  - 2. Line to Ground: 1200 V for 480Y/277 V, 1200 V for 208Y/120 V.
  - 3. Line to Line: 2000 V for 480Y/277 V, 1000 V for 208Y/120 V.
- F. SCCR: Equal or exceed 100 kA.
- G. Inominal Rating: 20 kA.

## 2.4 ENCLOSURES

- A. Indoor Enclosures: NEMA 250, Type 1.
- B. Outdoor Enclosures: NEMA 250, Type 4X.

## 2.5 CONDUCTORS AND CABLES

- A. Power Wiring: Same size as SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Class 2 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

## **PART 3 - EXECUTION**

### 3.1 INSTALLATION

- A. Comply with NECA 1.
- B. Install an OCPD or disconnect as required to comply with the UL listing of the SPD.
- C. Install SPDs with conductors between suppressor and points of attachment as short and straight as possible, and adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice and extend SPD leads unless specifically permitted by manufacturer. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
- D. Use crimped connectors and splices only. Wire nuts are unacceptable.
- E. Wiring:
  - 1. Power Wiring: Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
  - 2. Controls: Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

### 3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.

1. Compare equipment nameplate data for compliance with Drawings and Specifications.
  2. Inspect anchorage, alignment, grounding, and clearances.
  3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.
- B. An SPD will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

### 3.3 STARTUP SERVICE

- A. Complete startup checks according to manufacturer's written instructions.
- B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests, and reconnect them immediately after the testing is over.
- C. Energize SPDs after power system has been energized, stabilized, and tested.

### 3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate and maintain SPDs.

**END OF SECTION**

## SECTION 265100 - INTERIOR LIGHTING

### PART 1 - GENERAL

#### 1.1 SUMMARY

A. Section Includes:

1. Interior lighting fixtures, lamps, and ballasts.
2. Emergency lighting units.
3. Exit signs.
4. Lighting fixture supports.

B. Related Sections:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
2. Section 262726 "Wiring Devices" for manual wall-box dimmers for incandescent lamps.

#### 1.2 DEFINITIONS

- A. BF: Ballast factor.
- B. CCT: Correlated color temperature.
- C. CRI: Color-rendering index.
- D. HID: High-intensity discharge.
- E. LER: Luminaire efficacy rating.
- F. Lumen: Measured output of lamp and luminaire, or both.
- G. Luminaire: Complete lighting fixture, including ballast housing if provided.
- H. EPA: Environmental Protection Agency.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
1. Physical description of lighting fixture including dimensions.
  2. Emergency lighting units including battery and charger.
  3. Ballast, including BF.
  4. Energy-efficiency data.

5. Life, output (lumens, CCT, and CRI), and energy-efficiency data for lamps.
  6. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing & Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.
    - a. **Manufacturer Certified Data:** Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
- B. **Shop Drawings:** For nonstandard or custom lighting fixtures. Include plans, elevations, sections, details, and attachments to other work.
1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  2. **Wiring Diagrams:** For power, signal, and control wiring.
- C. **Installation instructions.**

#### 1.4 INFORMATIONAL SUBMITTALS

- A. **Coordination Drawings:** Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Lighting fixtures.
  2. Suspended ceiling components.
  3. Partitions and millwork that penetrate the ceiling or extends to within 12 inches of the plane of the luminaires.
  4. Ceiling-mounted projectors.
  5. Structural members to which suspension systems for lighting fixtures will be attached.
  6. Other items in finished ceiling including the following:
    - a. Air outlets and inlets.
    - b. Speakers.
    - c. Sprinklers.
    - d. Smoke and fire detectors.
    - e. Occupancy sensors.
    - f. Access panels.
  7. Perimeter moldings.

- B. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.
- C. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, from manufacturer.
- D. Field quality-control reports.
- E. Warranty: Sample of special warranty.

#### 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.
  - 1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

#### 1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
  - 2. Plastic Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
  - 3. Fluorescent-fixture-mounted, emergency battery pack: One for every 20 emergency lighting unit.
  - 4. Ballasts: One for every 100 of each type and rating installed. Furnish at least 5 of each type.
  - 5. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

#### 1.7 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910, complying with the IESNA Lighting Measurements Testing & Calculation Guides.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NFPA 70.

1.8 COORDINATION

- A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.9 WARRANTY

- A. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period for Emergency Lighting Unit Batteries: 10 years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining nine years.
  - 2. Warranty Period for Emergency Fluorescent Ballast and Self-Powered Exit Sign Batteries: Seven years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining six years.

**PART 2 - PRODUCTS**

2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, provide product indicated on Drawings.

2.2 GENERAL REQUIREMENTS FOR LIGHTING FIXTURES AND COMPONENTS

- A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
- B. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
- C. Metal Parts: Free of burrs and sharp corners and edges.
- D. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.
- E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
- F. Diffusers and Globes:

1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
    - a. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.
    - b. UV stabilized.
  2. Glass: Annealed crystal glass unless otherwise indicated.
- G. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
1. Label shall include the following lamp and ballast characteristics:
    - a. "USE ONLY" and include specific lamp type.
    - b. Lamp diameter code (T-4, T-5, T-8, T-12, etc.), tube configuration (twin, quad, triple, etc.), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.
    - c. Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.
    - d. Start type (preheat, rapid start, instant start, etc.) for fluorescent and compact fluorescent luminaires.
    - e. ANSI ballast type (M98, M57, etc.) for HID luminaires.
    - f. CCT and CRI for all luminaires.
- H. Electromagnetic-Interference Filters: Factory installed to suppress conducted electromagnetic interference as required by MIL-STD-461E. Fabricate lighting fixtures with one filter on each ballast indicated to require a filter.

### 2.3 BALLASTS FOR LINEAR FLUORESCENT LAMPS

- A. General Requirements for Electronic Ballasts:
1. Comply with UL 935 and with ANSI C82.11.
  2. Designed for type and quantity of lamps served.
  3. Ballasts shall be designed for full light output unless another BF, dimmer, or bi-level control is indicated.
  4. Sound Rating: Class A.
  5. Total Harmonic Distortion Rating: Less than 20 percent.
  6. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
  7. Operating Frequency: 42 kHz or higher.
  8. Lamp Current Crest Factor: 1.7 or less.
  9. BF: 0.88 or higher.
  10. Power Factor: 0.98 or higher.

11. Parallel Lamp Circuits: Multiple lamp ballasts shall comply with ANSI C82.11 and shall be connected to maintain full light output on surviving lamps if one or more lamps fail.
- B. luminaires controlled by occupancy sensors shall have programmed-start ballasts.
- C. Electronic Programmed-Start Ballasts for T8 Lamps: Comply with ANSI C82.11 and the following:
  1. Lamp end-of-life detection and shutdown circuit for T5 diameter lamps.
  2. Automatic lamp starting after lamp replacement.
- D. Single Ballasts for Multiple Lighting Fixtures: Factory wired with ballast arrangements and bundled extension wiring to suit final installation conditions without modification or rewiring in the field.
- E. Ballasts for Low-Temperature Environments:
  1. Temperatures 0 Deg F and Higher: Electronic type rated for 0 deg F starting and operating temperature with indicated lamp types.
  2. Temperatures Minus 20 Deg F and Higher: Electromagnetic type designed for use with indicated lamp types.

#### 2.4 BALLASTS FOR COMPACT FLUORESCENT LAMPS

- A. Description: Electronic-programmed rapid-start type, complying with UL 935 and with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated:
  1. Lamp end-of-life detection and shutdown circuit.
  2. Automatic lamp starting after lamp replacement.
  3. Sound Rating: Class A.
  4. Total Harmonic Distortion Rating: Less than 20 percent.
  5. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
  6. Operating Frequency: 20 kHz or higher.
  7. Lamp Current Crest Factor: 1.7 or less.
  8. BF: 0.95 or higher unless otherwise indicated.
  9. Power Factor: 0.95 or higher.
  10. Interference: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.

## 2.5 EXIT SIGNS

- A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
- B. Internally Lighted Signs:
  - 1. Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.
  - 2. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.
    - a. Battery: Sealed, maintenance-free, nickel-cadmium type.
    - b. Charger: Fully automatic, solid-state type with sealed transfer relay.
    - c. Operation: 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.
    - d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
    - e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

## 2.6 EMERGENCY LIGHTING UNITS

- A. General Requirements for Emergency Lighting Units: Self-contained units complying with UL 924.
  - 1. Battery: Sealed, maintenance-free, lead-acid type.
  - 2. Charger: Fully automatic, solid-state type with sealed transfer relay.
  - 3. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
  - 4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
  - 5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
  - 6. Wire Guard: Heavy-chrome-plated wire guard protects lamp heads or fixtures.
  - 7. Integral Time-Delay Relay: Holds unit on for fixed interval of 15 minutes when power is restored after an outage.

8. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
9. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

## 2.7 FLUORESCENT LAMPS

- A. All lamps shall be ECO/Low Mercury type and shall meet or pass the environmental protection agency toxic characteristics leaching procedure (TCLP) test.
- B. T8 rapid-start lamps, rated 32 W maximum, nominal length of 48 inches, 2800 initial lumens (minimum), CRI 75 (minimum), color temperature 3500 K, and average rated life 25,000 hours (minimum) unless otherwise indicated.
- C. T8 rapid-start lamps, rated 17 W maximum, nominal length of 24 inches, 1300 initial lumens (minimum), CRI 75 (minimum), color temperature 3500 K, and average rated life of 25,000 hours (minimum) unless otherwise indicated.
- D. Compact Fluorescent Lamps: 4-Pin, CRI 80 (minimum), color temperature 3500 K, average rated life of 10,000 hours at three hours operation per start, and suitable for use with dimming ballasts unless otherwise indicated.
  1. 13 W: T4, double or triple tube, rated 900 initial lumens (minimum).
  2. 18 W: T4, double or triple tube, rated 1200 initial lumens (minimum).
  3. 26 W: T4, double or triple tube, rated 1800 initial lumens (minimum).
  4. 32 W: T4, triple tube, rated 2400 initial lumens (minimum).
  5. 42 W: T4, triple tube, rated 3200 initial lumens (minimum).
  6. 57 W: T4, triple tube, rated 4300 initial lumens (minimum).
  7. 70 W: T4, triple tube, rated 5200 initial lumens (minimum).

## 2.8 LIGHTING FIXTURE SUPPORT COMPONENTS

- A. Comply with Section 260529 "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.
- C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.
- D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

- E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage.
- F. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.
- G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

### **PART 3 - EXECUTION**

#### **3.1 INSTALLATION**

- A. Lighting fixtures:
  - 1. Set level, plumb, and square with ceilings and walls unless otherwise indicated.
  - 2. Install lamps in each luminaire.
- B. Temporary Lighting: If it is necessary, and approved by Architect, to use permanent luminaires for temporary lighting, install and energize the minimum number of luminaires necessary. When construction is sufficiently complete, remove the temporary luminaires, disassemble, clean thoroughly, install new lamps, and reinstall.
- C. Remote Mounting of Ballasts: Distance between the ballast and fixture shall not exceed that recommended by ballast manufacturer. Verify, with ballast manufacturers, maximum distance between ballast and luminaire.
- D. Lay-in Ceiling Lighting Fixtures Supports: Use grid as a support element.
  - 1. Install ceiling support system rods or wires, independent of the ceiling suspension devices, for each fixture. Locate not more than 6 inches from lighting fixture corners.
  - 2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
  - 3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
  - 4. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.
- E. Suspended Lighting Fixture Support:
  - 1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
  - 2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.

3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
  4. Do not use grid as support for pendant luminaires. Connect support wires or rods to building structure.
- F. Air-Handling Lighting Fixtures: Install with dampers closed and ready for adjustment.
- G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

### 3.2 IDENTIFICATION

- A. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

### 3.3 FIELD QUALITY CONTROL

- A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.
- B. Verify that self-luminous exit signs are installed according to their listing and the requirements in NFPA 101.
- C. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

### 3.4 STARTUP SERVICE

- A. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Owner. Burn-in fluorescent and compact fluorescent lamps intended to be dimmed, for at least 100 hours at full voltage.

### 3.5 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark.
1. Adjust aimable luminaires in the presence of Architect.

**END OF SECTION**

## SECTION 265600 - EXTERIOR LIGHTING

### PART 1 - GENERAL

#### 1.1 SUMMARY

A. Section Includes:

1. Exterior luminaires with lamps and drivers.
2. Luminaire mounted photo electric relays.
3. Poles and accessories.
4. Luminaire lowering devices.

B. Related Sections:

1. Section 265100 "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of buildings.

#### 1.2 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color-rendering index.
- C. LER: Luminaire efficacy rating.
- D. Luminaire: Complete lighting fixture, including ballast housing if provided.
- E. Pole: Luminaire support structure, including tower used for large area illumination.
- F. Standard: Same definition as "Pole" above.

#### 1.3 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

- A. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied as stated in AASHTO LTS-4-M.
- B. Live Load: Single load of 500 lbf, distributed as stated in AASHTO LTS-4-M.
- C. Ice Load: Load of 3 lbf/sq. ft., applied as stated in AASHTO LTS-4-M Ice Load Map.
- D. Wind Load: Pressure of wind on pole and luminaire and banners and banner arms, calculated and applied as stated in AASHTO LTS-4-M.
1. Basic wind speed for calculating wind load for poles 50 feet high or less is 40 mph.

- a. Wind Importance Factor: 1.0.
- b. Minimum Design Life: 25 years.
- c. Velocity Conversion Factors: 1.0.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:
  - 1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
  - 2. Details of attaching luminaires and accessories.
  - 3. Details of installation and construction.
  - 4. Luminaire materials.
  - 5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, drivers, and accessories.
    - a. Testing Agency Certified Data: For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
    - b. Manufacturer Certified Data: Photometric data shall be certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
  - 6. Drivers, including energy-efficiency data.
  - 7. Lamps, including life, output, CCT, CRI, lumens, and energy-efficiency data.
  - 8. Materials, dimensions, and finishes of poles.
  - 9. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
  - 10. Anchor bolts for poles.
  - 11. Manufactured pole foundations.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 2. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
  - 3. Design calculations, certified by a qualified professional engineer, indicating strength of screw foundations and soil conditions on which they are based.

- 4. Wiring Diagrams: For power, signal, and control wiring.
- C. Samples: For products designated for sample submission in the Exterior Lighting Device Schedule. Each Sample shall include lamps and ballasts.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements in AASHTO LTS-4-M and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations by a professional engineer.
- B. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.
- C. Field quality-control reports.
- D. Warranty: Sample of special warranty.

#### 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires and poles to include in emergency, operation, and maintenance manuals.

#### 1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Led Lamps: One of each type and rating installed. Furnish at least one of each type.
  - 2. Glass and Plastic Lenses, Covers, and Other Optical Parts: One of each type and rating installed. Furnish at least one of each type.
  - 3. Led Drivers: One of each type and rating installed. Furnish at least one of each type.
  - 4. Globes and Guards: two of each of each type and rating installed. Furnish at least one of each type.

#### 1.8 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
- B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.

- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with IEEE C2, "National Electrical Safety Code."
- E. Comply with NFPA 70.

#### 1.9 DELIVERY, STORAGE, AND HANDLING

- A. Package aluminum poles for shipping according to ASTM B 660.
- B. Store poles on decay-resistant-treated skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.
- C. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

#### 1.10 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.
  - 1. Warranty Period for Luminaires: Five years from date of Substantial Completion.
  - 2. Warranty Period for Metal Corrosion: Five years from date of Substantial Completion.
  - 3. Warranty Period for Color Retention: Five years from date of Substantial Completion.
  - 4. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than three years from date of Substantial Completion.

### **PART 2 - PRODUCTS**

#### 2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, provide product indicated on Drawings.

## 2.2 GENERAL REQUIREMENTS FOR LUMINAIRES

- A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.
- B. Lateral Light Distribution Patterns: Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.
- C. Metal Parts: Free of burrs and sharp corners and edges.
- D. Sheet Metal Components: Corrosion-resistant aluminum unless otherwise indicated. Form and support to prevent warping and sagging.
- E. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.
- F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.
- G. Exposed Hardware Material: Stainless steel.
- H. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
- I. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.
- J. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:
  - 1. White Surfaces: 85 percent.
  - 2. Specular Surfaces: 83 percent.
  - 3. Diffusing Specular Surfaces: 75 percent.
- K. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- L. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.
- M. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
  2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
    - a. Color: As selected from manufacturer's standard catalog of colors.
- N. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
  2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
  3. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
  4. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.
    - a. Color: Dark bronze.
- O. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
1. Label shall include the following lamp and ballast characteristics:
    - a. "USES ONLY" and include specific lamp type.
    - b. CCT and CRI for all luminaires.
    - c. Have an IP65 rating.

## 2.3 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

- A. Comply with UL 773 or UL 773A.
- B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 and off at 4.5 to 10 fc with

15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.

1. Relay with locking-type receptacle shall comply with ANSI C136.10.
2. Adjustable window slide for adjusting on-off set points.

## 2.4 LED FIXTURES DRIVERS AND LAMPS

### A. Construction and Design

1. Consist of a die-cast A380 aluminum housing and door, with integral heat sink fins to optimize thermal management through conductive and convective cooling.
2. Have a modular component design for ease of maintenance and future upgrades.
3. Have the LED driver mounted in direct contact with the housing to promote low operating temperature and long life.
4. Be completely sealed against moisture and environmental contaminants to an IP65 rating.
5. Have an EPA rating of 0.8 ft<sup>2</sup> or less for optimized pole wind loading.
6. Weigh 35 lbs. or less for ease of installation.

### B. Finish

1. Exterior parts shall be protected by a zinc-infused Super Durable TGIC thermoset powder coat finish to provide superior resistance to corrosion and weathering.
2. Shall employ a tightly controlled multi-stage process to ensure a minimum 3 mils thickness for a finish that can withstand extreme climate changes without cracking or peeling.

### C. Light Engines

1. Consist of LEDs mounted to a metal-core circuit board and covered by precision-molded UV-stabilized acrylic lenses, of a design engineered for area lighting distributions.
2. Be mounted to the luminaire housing via an interstitial thermal spreader pad.
3. Color rendering, 4000K (67 min. CRI).
4. Be integrated and perform such that the luminaire has zero uplight and qualifies as a Nighttime Friendly product, meaning it is consistent with the LEED criteria for eliminating wasteful uplight.
5. Be gasketed and completely sealed against moisture and environmental contaminants to an IP66 rating.
6. Be compatible with optional low-profile house-side shields.

### D. Life/Lumen Maintenance

1. The luminaire shall be projected (per IESNA TM-21-11) to maintain 87% of initial lumen output after 100,000 operating hours in an average ambient of 40°C (104°F), based on 10,000 hours of LED testing (per IESNA LM-80-08).

E. Electrical

1. Use, as standard, Class 1 constant current electronic drivers with a power factor >90%, THD <20%, and an expected life of 100,000 hours with <1% failure rate, per applicable MilSpec and Telcordia MTBF standards. Drivers shall offer multiple drive currents, up to 700 mA, and multiple voltages, including an auto-sensing 120-277V, and 480V, operating at 60 Hz. Drivers shall include an automatic thermal fold-back feature, such that if the driver's temperature rises above its design limit, the driver automatically reduces current to bring itself below the temperature limit.
2. Use, as standard, an easily-serviceable, UL recognized surge protection device that is wired in front of the light engine(s) and driver(s) and protects the luminaire to a minimum Category C Low (per ANSI/IEEE C62.41.2).
3. Consume 0 watts in the off-state, excluding control devices.

2.5 GENERAL REQUIREMENTS FOR POLES AND SUPPORT COMPONENTS

A. Structural Characteristics: Comply with AASHTO LTS-4-M.

1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in "Structural Analysis Criteria for Pole Selection" Article.
2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.

B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.

1. Materials: Shall not cause galvanic action at contact points.
2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.
3. Anchor-Bolt Template: Steel.

D. Handhole: Oval-shaped, with minimum clear opening of 2-1/2 by 5 inches, with cover secured by stainless-steel captive screws.

- E. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."
- F. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.
- G. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4-M.

## 2.6 STEEL POLES

- A. Poles: Comply with ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psig (317 MPa); one-piece construction up to 40 feet (12 m) in height with access handhole in pole wall.
  - 1. Shape: Round, straight.
  - 2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- B. Steel Mast Arms: Single-arm or Truss type, continuously welded to pole attachment plate. Material and finish same as pole.
- C. Brackets for Luminaires: Detachable, cantilever, without underbrace.
  - 1. Adapter fitting welded to pole, allowing the bracket to be bolted to the pole mounted adapter, then bolted together with galvanized-steel bolts.
  - 2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire.
  - 3. Match pole material and finish.
- D. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
- E. Steps: Fixed steel, with nonslip treads, positioned for 15-inch (381-mm) vertical spacing, alternating on opposite sides of pole; first step at elevation 10 feet (3 m) above finished grade.
- F. Intermediate Handhole and Cable Support: Weathertight, 3-by-5-inch (76-by-127-mm) handhole located at midpoint of pole with cover for access to internal welded attachment lug for electric cable support grip.
- G. Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Section 260526 "Grounding and Bonding for Electrical

Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

- H. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable times a 5.0 safety factor.
- I. Platform for Lamp and Ballast Servicing: Factory fabricated of steel with finish matching that of pole.
- J. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.
- K. Galvanized Finish: After fabrication, hot-dip galvanize complying with ASTM A 123/A 123M.
- L. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
  - 1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or with SSPC-SP 8, "Pickling."
  - 2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
  - 3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
    - a. Color: As indicated by manufacturer's designations.

### **PART 3 - EXECUTION**

#### **3.1 LUMINAIRE INSTALLATION**

- A. Install lamps in each luminaire.
- B. Fasten luminaire to indicated structural supports.
  - 1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
- C. Adjust luminaires that require field adjustment or aiming
- D. Use a die-cast arm, integral to the luminaire housing and include

### 3.2 POLE INSTALLATION

- A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.
- B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on Drawings:
  - 1. Fire Hydrants and Storm Drainage Piping: 60 inches.
  - 2. Water, Gas, Electric, Communication, and Sewer Lines: 10 feet.
  - 3. Trees: 15 feet from tree trunk.
- C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Section 033000 "Cast-in-Place Concrete."
- D. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
  - 1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
  - 2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
  - 3. Install base covers unless otherwise indicated.
  - 4. Use a short piece of 1/2-inch- diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
- E. Raise and set poles using web fabric slings (not chain or cable).

### 3.3 CORROSION PREVENTION

- A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.
- B. Steel Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

### 3.4 GROUNDING

- A. Ground metal poles and support structures according to Section 260526 "Grounding and Bonding for Electrical Systems."
  - 1. Install grounding electrode for each pole unless otherwise indicated.
  - 2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

### 3.5 FIELD QUALITY CONTROL

- A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
- B. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.
  - 1. Verify operation of photoelectric controls.
- C. Illumination Tests:
  - 1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IESNA testing guide(s):
    - a. IESNA LM-50, "Photometric Measurements of Roadway Lighting Installations."
    - b. IESNA LM-64, "Photometric Measurements of Parking Areas."
    - c. IESNA LM-72, "Directional Positioning of Photometric Data."
- D. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

### 3.6 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain luminaire lowering devices.

**END OF SECTION**

## SECTION 280526 - GROUNDING AND BONDING FOR ELECTRONIC SAFETY AND SECURITY

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section Includes:
1. Grounding conductors.
  2. Grounding connectors.
  3. Grounding busbars.

#### 1.2 DEFINITIONS

- A. Signal Ground: The ground reference point designated by manufacturer of the system that is considered to have zero voltage.

#### 1.3 ACTION SUBMITTALS

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

### PART 2 - PRODUCTS

#### 2.1 CONDUCTORS

- A. **Manufacturers:** Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. **Harger Lightning and Grounding.**
  2. **Panduit Corp.**
  3. **Tyco Electronics Corp.**
- B. Comply with UL 486A-486B.
- C. Insulated Conductors: Stranded copper wire, green or green with yellow stripe insulation, insulated for 600 V, and complying with UL 83.
1. Ground wire for custom-length equipment ground jumpers shall be No. 6 AWG, 19-strand, UL-listed, Type THHN wire.
- D. Bare Copper Conductors:
1. Solid Conductors: ASTM B 3.
  2. Stranded Conductors: ASTM B 8.

3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmils, 14 strands of No. 17 AWG conductor, and 1/4 inch in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Tinned-copper tape, braided conductors terminated with two-hole copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

## 2.2 CONNECTORS

- A. Irreversible connectors listed for the purpose. Listed by an NRTL as complying with NFPA 70 for specific types, sizes, and combinations of conductors and other items connected. Comply with UL 486A-486B.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  1. Burndy; Part of Hubbell Electrical Systems.
  2. Chatsworth Products, Inc.
  3. Harger Lightning and Grounding.
  4. Panduit Corp.
  5. Tyco Electronics Corp.
- C. Compression Wire Connectors: Crimp-and-compress connectors that bond to the conductor when the connector is compressed around the conductor. Comply with UL 467.
  1. Electroplated tinned copper, C and H shaped.
- D. Busbar Connectors: Cast silicon bronze, solderless compression-type mechanical connector; with a long barrel and two holes spaced on 5/8- or 1-inch centers for a two-bolt connection to the busbar.
- E. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

## 2.3 GROUNDING BUSBARS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  1. Chatsworth Products, Inc.
  2. Harger Lightning and Grounding.
  3. Panduit Corp.
- B. Rack and Cabinet Grounding Busbars: Rectangular bars of hard-drawn solid copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed

as complying with UL 467, and complying with J-STD-607-A. Predrilling shall be with holes for use with lugs specified in this Section.

1. Cabinet-Mounted Busbar: Terminal block, with stainless-steel or copper-plated hardware for attachment to the cabinet.
2. Rack-Mounted Horizontal Busbar: Designed for mounting in 19- or 23-inch equipment racks. Include a copper splice bar for transitioning to an adjoining rack, and stainless-steel or copper-plated hardware for attachment to the rack.
3. Rack-Mounted Vertical Busbar: 72 or 36 inches stainless-steel or copper-plated hardware for attachment to the rack.

### **PART 3 - EXECUTION**

#### **3.1 INSTALLATION**

- A. Comply with IEEE 1100, "Recommended Practice for Power and Grounding Electronic Equipment."
  1. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
  2. Bond shields and drain conductors to ground at only one point in each circuit.
- B. Signal Ground:
  1. For each system, establish the signal ground and label that location as such.
  2. Bond the signal ground to the alternating-current (ac) power system service by connecting to one of the following listed locations, using insulated No. 6 AWG, stranded, Type THHN wire:
    - a. Grounding bar in an electrical power panelboard if located in the same room or space as the signal ground.
    - b. Telecommunications grounding busbar.
- C. Comply with NECA 1.

#### **3.2 APPLICATION**

- A. Conductors: Install solid conductor for No. 8 AWG and smaller and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Grounding and Bonding Conductors:

1. Install in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than eight times the diameter of the conductor. No one bend may exceed 90 degrees.
2. Install without splices.
3. Support at not more than 36-inch intervals.

### 3.3 CONNECTIONS

- A. Stacking of conductors under a single bolt is not permitted when connecting to busbars.
- B. Assemble the wire connector to the conductor, complying with manufacturer's written instructions and as follows:
  1. Use crimping tool and the die specific to the connector.
  2. Pretwist the conductor.
  3. Apply an antioxidant compound to all bolted and compression connections.
- C. Shielded Cable: Bond the shield of shielded cable to the signal ground. Comply with TIA/EIA-568-B.1 and TIA/EIA-568-B.2 when grounding screened, balanced, twisted-pair cables.
- D. Rack- and Cabinet-Mounted Equipment: Bond powered equipment chassis to the cabinet or rack grounding bar. Power connection shall comply with NFPA 70; the equipment grounding conductor in the power cord of cord- and plug-connected equipment shall be considered as a supplement to bonding requirements in this Section.

### 3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
  1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
- C. Grounding system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

**END OF SECTION**

## **SECTION 280528 - PATHWAYS FOR ELECTRONIC SAFETY AND SECURITY**

### **PART 1 - GENERAL**

#### **1.1 SUMMARY**

**A. Section Includes:**

1. Metal conduits, tubing, and fittings.
2. Surface pathways.
3. Boxes, enclosures, and cabinets.
4. Handholes and boxes for exterior underground cabling.

**B. Related Requirements:**

1. Section 260533 "Raceways and Boxes for Electrical Systems" for conduits, wireways, surface raceways, boxes, enclosures, cabinets, handholes, and faceplate adapters serving electrical systems.

#### **1.2 ACTION SUBMITTALS**

**A. Product Data:** For surface pathways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

**B. LEED Submittals:**

1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.

**C. Shop Drawings:** For custom enclosures and cabinets.

#### **1.3 INFORMATIONAL SUBMITTALS**

**A. Seismic Qualification Certificates:** For pathway racks, enclosures, cabinets, and equipment racks and their mounting provisions, including those for internal components, from manufacturer.

### **PART 2 - PRODUCTS**

#### **2.1 METAL CONDUITS, TUBING, AND FITTINGS**

**A. General Requirements for Metal Conduits and Fittings:**

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with TIA-569-B.

- B. GRC: Comply with ANSI C80.1 and UL 6.
- C. ARC: Comply with ANSI C80.5 and UL 6A.
- D. EMT: Comply with ANSI C80.3 and UL 797.
- E. FMC: Comply with UL 1; zinc-coated steel.
- F. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
  - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
  - 2. Fittings for EMT:
    - a. Material: Steel.
    - b. Type: Setscrew.
  - 3. Expansion Fittings: PVC or steel to match conduit type, complying with UL-467, rated for environmental conditions where installed, and including flexible external bonding jumper.
- G. Joint Compound for GRC or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

## 2.2 NONMETALLIC CONDUITS, TUBING, AND FITTINGS

- A. General Requirements for Nonmetallic Conduits and Fittings:
  - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  - 2. Comply with TIA-569-B.
- B. ENT: Comply with NEMA TC 13 and UL 1653.
- C. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- D. Continuous HDPE: Comply with UL 651B.
- E. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
- F. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

## 2.3 SURFACE PATHWAYS

- A. General Requirements for Surface Pathways:
  - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  - 2. Comply with TIA-569-B.
- B. Surface Metal Pathways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish.
- C. Tele-Power Poles:
  - 1. Material: Galvanized steel with baked-enamel finish.
  - 2. Fittings and Accessories: Dividers, end caps, covers, cutouts, wiring harnesses, devices, mounting materials, and other fittings shall match and mate with tele-power pole as required for complete system.

## 2.4 BOXES, ENCLOSURES, AND CABINETS

- A. General Requirements for Boxes, Enclosures, and Cabinets:
  - 1. Comply with TIA-569-B.
  - 2. Boxes, enclosures and cabinets installed in wet locations shall be listed for use in wet locations.
- B. Sheet-Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- C. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- D. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- E. Metal Floor Boxes:
  - 1. Material: Cast or sheet metal.
  - 2. Type: Fully adjustable.
  - 3. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- G. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.
- H. Device Box Dimensions: **4 inches square by 2-1/8 inches deep.**

- I. Gangable boxes are prohibited.
- J. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
- K. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.
  - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
  - 2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- L. Cabinets:
  - 1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
  - 2. Hinged door in front cover with flush latch and concealed hinge.
  - 3. Key latch to match panelboards.
  - 4. Metal barriers to separate wiring of different systems and voltage.
  - 5. Accessory feet where required for freestanding equipment.
  - 6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

## 2.5 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND CABLING

- A. General Requirements for Handholes and Boxes:
  - 1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
  - 2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  - 3. Comply with TIA-569-B.
- B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.
  - 1. Standard: Comply with SCTE 77.
  - 2. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
  - 3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.

4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering, "ELECTRIC."

### **PART 3 - EXECUTION**

#### **3.1 PATHWAY APPLICATION**

- A. Outdoors: Apply pathway products as specified below unless otherwise indicated:
  1. Exposed Conduit: GRC.
  2. Underground Conduit: RNC, Type EPC-40-PVC, direct buried concrete encased.
  3. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
- B. Indoors: Apply pathway products as specified below unless otherwise indicated:
  1. Exposed, Not Subject to Physical Damage: EMT.
  2. Exposed, Not Subject to Severe Physical Damage: EMT.
  3. Exposed and Subject to Severe Physical Damage: GRC.
  4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
  5. Damp or Wet Locations: GRC.
  6. Pathways for Optical-Fiber or Communications Cable in Spaces Used for Environmental Air: EMT.
  7. Boxes and Enclosures: NEMA 250 Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.
- C. Minimum Pathway Size: **3/4-inch** trade size. Minimum size for optical-fiber cables is **1 inch**.
- D. Pathway Fittings: Compatible with pathways and suitable for use and location.
  1. Rigid Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
  2. EMT: Use setscrew, steel fittings. Comply with NEMA FB 2.10.
  3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
- E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- F. Install surface pathways only where indicated on Drawings.
- G. Do not install nonmetallic conduit where ambient temperature exceeds **120 deg F**.

### 3.2 INSTALLATION

- A. Comply with NECA 1, NECA 101, and TIA-569-B for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum pathways. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.
- B. Keep pathways at least **6 inches** away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.
- C. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- D. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications wiring conduits for which only two 90-degree bends are allowed. Support within **12 inches** of changes in direction.
- E. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- F. Pathways Embedded in Slabs:
  - 1. Run conduit larger than **1-inch** trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure pathways to reinforcement at maximum **10-foot** intervals.
  - 2. Arrange pathways to cross building expansion joints at right angles with expansion fittings.
  - 3. Arrange pathways to keep a minimum of **1 inch** of concrete cover in all directions.
  - 4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
- G. Stub-ups to Above Recessed Ceilings:
  - 1. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- H. Coat field-cut threads on PVC-coated pathway with a corrosion-preventing conductive compound prior to assembly.
- I. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install insulated bushings on conduits terminated with locknuts.
- J. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

- K. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to conduit assembly to assure a continuous ground path.
- L. Spare Pathways: Install pull wires in empty pathways. Cap underground pathways designated as spare above grade alongside pathways in use.
- M. Surface Pathways:
  - 1. Install surface pathway for surface electrical outlet boxes only where indicated on Drawings.
- N. Install pathway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound.
- O. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all pathways at the following points:
  - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
  - 2. Where an underground service pathway enters a building or structure.
  - 3. Where otherwise required by NFPA 70.
- P. Expansion-Joint Fittings:
  - 1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed **30 deg F**, and that has straight-run length that exceeds **25 feet**. Install in each run of aboveground RMC and EMT that is located where environmental temperature change may exceed **100 deg F** and that has straight-run length that exceeds **100 feet**.
  - 2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
    - a. Outdoor Locations Not Exposed to Direct Sunlight: **125 deg F** temperature change.
    - b. Outdoor Locations Exposed to Direct Sunlight: **155 deg F** temperature change.
    - c. Indoor Spaces Connected with Outdoors without Physical Separation: **125 deg F** temperature change.
  - 3. Install fitting(s) that provide expansion and contraction for at least **0.00041 inch per foot of length of straight run per deg F** of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least **0.000078 inch per foot of length of straight run per deg F** of temperature change for metal conduits.

4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
  5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- Q. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of **72 inches** of flexible conduit forequipment subject to vibration, noise transmission, or movement; and for transformers and motors.
- R. Mount boxes at heights indicated on Drawings according to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.
- S. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

### 3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe less than **6 inches** in nominal diameter.
2. Install backfill as specified in Section 312000 "Earth Moving."
3. After installing conduit, backfill and compact. After placing controlled backfill to within **12 inches** of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
4. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
  - a. Couple steel conduits to ducts with adapters designed for this purpose.
  - b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of **60 inches** from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
5. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

### 3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

- B. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures **1 inch** above finished grade.
- C. Install handholes with bottom below frost line, 12 inches below grade.
- D. Field cut openings for conduits according to enclosure manufacturer's written instructions.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRONIC SAFETY AND SECURITY PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electronic Safety and Security Pathways and Cabling."

3.6 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.7 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.

**END OF SECTION**

**SECTION 280544 - SLEEVES AND SLEEVE SEALS FOR ELECTRONIC SAFETY  
AND SECURITY PATHWAYS AND CABLING**

**PART 1 - GENERAL**

1.1 SUMMARY

A. Section Includes:

1. Sleeves for pathway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. LEED Submittals:

1. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.

**PART 2 - PRODUCTS**

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.

2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; **0.0239-inch** minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.
- C. Sleeves for Rectangular Openings:
1. Material: Galvanized-steel sheet.
  2. Minimum Metal Thickness:
    - a. For sleeve cross-section rectangle perimeter less than **50 inches** and with no side larger than **16 inches**, thickness shall be **0.052 inch**.
    - b. For sleeve cross-section rectangle perimeter **50 inches** or more and one or more sides larger than **16 inches**, thickness shall be **0.138 inch**.

## 2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - a. **Advance Products & Systems, Inc.**
    - b. **CALPICO, Inc.**
    - c. **Metraflex Company (The).**
    - d. **Pipeline Seal and Insulator, Inc.**
    - e. **Proco Products, Inc.**
  2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
  3. Pressure Plates: Carbon steel.
  4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

### 2.3 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.
  - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - a. **Presealed Systems.**

### 2.4 GROUT

- A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: **5000-psi**, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

### 2.5 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
  - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
  - 2. Sealant shall have VOC content of 31 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Silicone Foams: Multicomponent, silicone-based, liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

## PART 3 - EXECUTION

### 3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.

- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
  - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
    - a. Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
    - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
  - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
  - 3. Size pipe sleeves to provide **1/4-inch** annular clear space between sleeve and pathway or cable unless sleeve seal is to be installed.
  - 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
  - 5. Install sleeves for floor penetrations. Extend sleeves installed in floors **2 inches** above finished floor level. Install sleeves during erection of floors.
- D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
  - 1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
  - 2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.
- E. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for **1-inch** annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for **1-inch** annular clear space between pathway or cable and sleeve for installing sleeve-seal system.

### 3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at pathway entries into building.

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

### 3.3 SLEEVE-SEAL-FITTING INSTALLATION

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

**END OF SECTION**

## **SECTION 281300 - ACCESS CONTROL**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Security Management System (SMS) to include Access Control, Identity Management, Intrusion Detection & Alarm Point Monitoring, Video Surveillance, and Intercom - Communications
  - 2. One or more security SMS networked workstations.
  - 3. Security SMS operating system and application software.
  - 4. Security access controllers connected to high-speed electronic-data transmission network.

#### **1.3 RELATED SECTIONS**

- A. Section 087100 – Door Hardware, for interface to building access control system.
- B. Section 111233 – Parking Gates, for interface to building access control and intercom systems.
- C. Section 283111 – Digital, Addressable Fire-Alarm System, for interface to building fire alarm system.
- D. Section 323111 – Slide Gate Operator, for interface to building access control and intercom systems.

#### **1.4 REFERENCES**

- 1. Reference Standards: Systems specified in this Section will meet or exceed the requirements of the following:
  - a. Federal Communications Commission (FCC):
    - 1) FCC Part 15 – Radio Frequency Device
    - 2) FCC Part 68 – Connection of Terminal Equipment to the Telephone Network
  - b. Underwriters Laboratories (UL):

- 1) UL294 – Access Control System Units
  - 2) UL1076 – Proprietary Burglar Alarm Units and Systems
- c. National Fire Protection Association (NFPA):
- 1) NFPA70 – National Electrical Code
- d. Electronic Industries Alliance (EIA):
- 1) RS232C – Interface between Data Terminal Equipment and Data Communications Equipment Employing Serial Binary Data Interchange
  - 2) RS485 – Electrical Characteristics of Generators and Receivers for use in Balanced Digital Multi-Point Systems
- e. Federal Information Processing Standards (FIPS):
- 1) Advanced Encryption Standard (AES) (FIPS 197)
  - 2) FIPS 201: Personal Identity Verification (PIV) of Federal Employees and Contractors
- f. Homeland Security Presidential Directive 12 (HSPD-12)

## 1.5 DEFINITIONS

- A. AGC: Automatic gain control.
- B. B/W: Black and white.
- C. CCD: Charge-coupled device.
- D. CCTV: Closed-circuit television.
- E. Central Station: All SMS panels and servers
- F. CPU: Central processing unit.
- G. Credential: Data assigned to an entity and used to identify that entity.
- H. dpi: Dots per inch.
- I. DTS: Digital Termination Service. A microwave-based, line-of-sight communication provided directly to the end user.
- J. FTP: File transfer protocol.
- K. GFI: Ground fault interrupter.
- L. KVM: Rack Mountable Keyboard, Video, & Mouse

- M. I/O: Input/Output.
- N. Identifier: A credential card; keypad personal identification number; or code, biometric characteristic, or other unique identification entered as data into the entry-control database for the purpose of identifying an individual. Where this term is presented with an initial capital letter, this definition applies.
- O. IP: Internet protocol.
- P. LAN: Local area network.
- Q. LAN: Local area network.
- R. Location: A Location on the network having a PC-to-controller communications link, with additional controllers at the Location connected to the PC-to-controller link with a TIA 485-A communications loop. Where this term is presented with an initial capital letter, this definition applies.
- S. MPEG: Moving picture experts group.
- T. NTSC: National Television System Committee.
- U. PC: Personal computer.
- V. PC: Personal computer. Applies to the central station, workstations, and file servers.
- W. PCI Bus: Peripheral Component Interconnect. A peripheral bus providing a high-speed data path between the CPU and the peripheral devices such as a monitor, disk drive, or network.
- X. PDF: Portable Document Format. The file format used by the Acrobat document-exchange-system software from Adobe.
- Y. PTZ: Pan-tilt-zoom.
- Z. RAID: Redundant array of independent disks.
- AA. RAS: Remote access services.
- BB. RF: Radio frequency.
- CC. RFI: Radio-frequency interference.
- DD. ROM: Read-only memory. ROM data are maintained through losses of power.
- EE. SMS: Security Management System

- FF. Systems Integration: The bringing together of components of several systems containing interacting components to achieve indicated functional operation of combined systems.
- GG. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.
- HH. TCP: Transmission control protocol - connects hosts on the Internet.
- II. TWAIN: Technology without an Interesting Name. A programming interface that lets a graphics application, such as an image editing program or desktop publishing program, activate a scanner, frame grabber, or other image-capturing device.
- JJ. UPS: Uninterruptible power supply.
- KK. UPS: Uninterruptible power supply.
- LL. UPS: Uninterruptible power supply.
- MM. USB: Universal serial bus.
- NN. WAN: Wide area network
- OO. WAN: Wide area network.
- PP. WAV: The digital audio format used in Microsoft Windows.
- QQ. Wiegand: Patented magnetic principle that uses specially treated wires embedded in the credential card.
- RR. Windows: Operating system by Microsoft Corporation.
- SS. WMP: Windows media player.
- TT. Workstation: A PC with software that is configured for specific, limited security-system functions.
- UU. WYSIWYG: What You See Is What You Get. Text and graphics appear on the screen the same as they will in print.

## 1.6 SUMMARY

- A. The work detailed in this specification and associated drawings are an expansion of the Owner's existing Security Management System (SMS) which protects numerous other facilities. The products utilized on this project must be compatible with and must be supported by the Owner's SMS manufacturer. The existing platform includes Honeywell's Prowatch and Maxpro products. Where specific product models are listed in this specification there shall be no substitutions

permitted as these models are required for manufacturer compatibility. All potential vendors of this project must understand that adding additional devices and functionality for this project will require programming additions and programming changes to an existing, operational SMS. In order to ensure continuity of service throughout the enterprise and compliance with standards the successful vendor will be required to arrange for all Honeywell software programming with the Owner's Security Integrator of record. This Security Integration firm is Advantech headquartered in Dover, DE. The point of contact is Lee Thompson, leet@advantechsecurity.net.

- B. Work and products provided must conform to the State of Delaware's Building Access Security Standard, SE-ACCESS-001. This standard as authorized by Delaware Law, Title 29, Chapter 90C mandates the use of specific technology and products to establish consistency in both quality and the security as well as interoperability.

#### 1.7 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Reference each product to a location on Drawings. Test and evaluation data presented in Product Data will comply with SIA BIO-01.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - 1. Manufacturer's Product Data: Submit manufacturer's data sheets indicating systems and components proposed for use.
  - 2. Shop Drawings: Submit complete shop drawings including connection diagrams for interfacing equipment, list of connected equipment, and locations for major equipment components. Include letter from security management system (SMS) manufacture, certifying the shop drawing's riser diagram (point-to-point) are accurate.
  - 3. Record Drawings: During construction maintain record drawings indicating location of equipment and wiring. Submit an electronic version of record drawings not later than Substantial Completion of the project.
  - 4. Operation and Maintenance Data: Submit manufacturer's operation and maintenance data, customized to the system installed. Include system and operator manuals diagrams for cable management system.
  - 5. Wiring Diagrams. For power, signal, and control wiring. Show typical wiring schematics including the following:
    - a. SMS panels and servers locations.
    - b. SMS field equipment locations.
    - c. Mounting heights of all SMS equipment.

## 1.8 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For SMS Integrator / Installer will provide manufactures documentation indicating SMS Integrator / Installer hold the appropriate certifications for the specified systems and software.
1. Honeywell ProWatch Platinum Certification to document that the SMS Integrator / Installer is integration capable.
  2. Honeywell MaxPro Video Management Certification.
  3. Honeywell Advanced Macro and MGP Certification.
  4. Microsoft Certified Professional
  5. Microsoft Certified System Administrator
  6. CompTIA Network + Certified
  7. CompTIA A+ Certified
  8. Master T1 Electrical License – State of Delaware
  9. Class I Fire Alarm Signaling Systems Licensing – State of Delaware
  10. Business License – State of Delaware

## 1.9 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For security system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
1. Microsoft Windows software documentation.
  2. PC installation and operating documentation, manuals, and software for the PC and all installed peripherals. Software will include system restore, emergency boot diskettes, and drivers for all installed hardware. Provide separately for each PC.
  3. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy submittal.
  4. System installation and setup guides with data forms to plan and record options and setup decisions.

## 1.10 QUALITY ASSURANCE

- A. Manufacturer: Minimum ten years' experience in manufacturing and maintaining Security Management Systems. Manufacturer will be Microsoft Gold Certified.
- B. Installer and Security Integrator must be Platinum certified by Honeywell Integrated Security Dealer Service Certification Program (DSCP). Platinum certification ensures that the Installed and Security Integrator is Integration Capable and has met the highest standards of technical competence and customer service.
- C. Installer and Security Integrator must be PROWATCH Security Management System (SMS) certified by Honeywell Integrated Security. Certification must be

evidenced by the full time employment of no less than five PROWATCH SMS certified (successful completion of manufacturer training) technicians

- D. Installer and Security Integrator must be MaxPro Video Management System (PROWATCH Video Manager) certified by Honeywell Integrated Security. Certification must be evidenced by the full time employment of no less than five MaxPro VMS certified (successful completion of manufacturer training) technicians.

#### 1.11 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials in manufacturer's labeled packages. Store and handle in accordance with manufacturer's requirements.

#### 1.12 MAINTENANCE MATERIAL SUBMITTALS

- A. Deliver materials in manufacturer's labeled packages. Store and handle in accordance with manufacturer's requirements.

#### 1.13 PROJECT CONDITIONS

- A. Environmental Conditions: All SMS products will be properly listed for the environment in which they are to be installed.

### **PART 2 - PRODUCTS**

#### 2.1 MANUFACTURERS

- A. Security Management System (SMS) & Subsystems: To ensure compatibility and interoperability with the Owner's existing SMS the following products must be used. Honeywell ProWatch, MaxPro and Vista platforms.

#### 2.2 DESCRIPTION

- A. System Software: Software Requirements: The Security Management System will be a modular and network- enabled access control system. The Security Management System will be capable of controlling multiple remote sites, alarm monitoring, video imaging, ID badging, paging, digital video and CCTV switching and control that allows for easy expansion or modification of inputs and remote control stations. The Security Management System control at a central computer location will be under the control of a single software program and will provide full integration of all components. It will be alterable at any time depending upon facility requirements. Security Management System reconfiguration will be accomplished online through system programming. **ALL REQUIRED CARD READER LICENSES, CAMERA LICNESES AND PROWATCH/MAXPRO CLIENT LICENCE(S) WILL BE PROVIDED AS A PART OF THIS PROJECT. TO ENSURE THAT THERE WILL BE NO INTERRUPTION OF SERVICE TO OTHER OWNER FACILITIES AND**

**TO ENSURE CONSISTANCY IN CONFIGURATION, THE SMS INTEGRATOR / INSTALLER WILL UTILIZE THE OWNER'S HONEYWELL INTEGRATOR OF RECORD FOR THE INSTALLATION OF ADDITIONAL LICENSES AND SYSTEM PROGRAMMING.**

1. Multiuser and multitasking to allow for independent activities and monitoring to occur simultaneously at different workstations. The Security Management System will support multiple operator workstations via local area network/wide area network (LAN/WAN). The communications between the workstations and the server computer will utilize the TCP/IP standard over industry standard IEEE 802.3 (Ethernet). The communications between the server and workstations will be supervised, and will automatically generate alarm messages when the server is unable to communicate with a workstation. The operators on the network server will have the capability to log on to workstations and remotely configure devices for the workstation. Standard operator permission levels will be enforced, with full operator audit.
2. Concurrent Licensing: The Security Management System will support concurrent client workstation licensing. The Security Management System application will be installed on any number of client workstations, and will provide the ability for any of the client workstations to connect to the database server as long as the maximum number of concurrent connections purchased has not been exceeded.
3. Security Key: The Security Management System will only require a single security key dongle to be present on the database server for the Security Management System to operate. Security keys will not be required at the client workstations. The Security Management System will allow a user to read the information that is programmed on the server security key dongle. The Security Management System will support export of the information using the 'Export Dongle information' button, which will allow the user to forward to the integrator when upgrading new dongle features.
4. Access Control Software Suite: The Security Management System will offer a security management software suite available in four scalable versions: Lite, Professional, Corporate, and Enterprise Editions. The Security Management System platform will offer a complete access control solution: alarm monitoring, video imaging, ID badging and video surveillance control.
  - a. Corporate Edition: The Security Management System will operate in the Windows Server 2003 (32-bit) or Windows Server 2008 (32-bit and 64-bit) environment and utilize SQL 2005 (32-bit) or SQL 2008 (32-bit or 64-bit) as the database engine.
5. Terminal Services: The Security Management System will support Windows Server 2003/2008 Terminal Services. Terminal Services will allow the Security Management System server application to reside on the

Windows Terminal Server. Operating systems supporting a standard web browser will be capable of utilizing the thin client architecture. The Security Management System will support unlimited connections, based on concurrent licensing, to the Security Management System software. Full functionality will be obtained through the intranet connection allowing full administration and monitoring without the need for a local installation.

6. Relational Database Management System: The Security Management System will support industry standard relational database management systems. This will include relational database management system Microsoft SQL Server 2005/2008.
7. Database Partitioning: The Security Management System will provide the option to restrict access to sensitive information by user ID.
8. Memory: Proprietary software programs and control logic information used to coordinate and drive system hardware will be stored in read-only memory.
9. LDAP/ Microsoft Active Directory Services: The Security Management System will provide support of Lightweight Directory Access Protocol (LDAP) for enabling the user to locate organizations, individuals, and other resources such as files and devices in a network, whether on the public internet or on a private intranet. The Security Management System will provide a direct link to Microsoft Active Directory Services. The Security Management System will allow the transfer of Active Directory users into the database via the Data Transfer Utility. Conversely, Security Management System users will be capable of being exported to the Active Directory
10. Unicode: The Security Management System will utilize Unicode worldwide character set standard. The Security Management System will support double-byte character sets to facilitate adaptation of the Security Management System user interface and documentation to new international markets. Language support will include at a minimum English, Spanish, Portuguese, French, German and Simple Chinese.
11. Encryption: The Security Management System will provide multiple levels of data encryption
  - a. True 128-bit AES data encryption between the host and intelligent controllers. The encryption will ensure data integrity that is compliant with the requirements of FIPS-197 and SCIF environments. Master keys will be downloaded to the intelligent controller, which will then be authenticated through the Security Management System based on a successful match.
  - b. Transparent database encryption, including log files and backups.
  - c. SQL secure connections via SSL.
12. Supervised Alarm Points: Both supervised and non-supervised alarm point monitoring will be provided. Upon recognition of an alarm, the system

will be capable of switching CCTV cameras that are associated with the alarm point.

13. Compliance and Validation: The Security Management System will incorporate signature authentication where modifications to Security Management System resources will require either a single or dual signature authentication. Administrators will have the ability to select specified devices in the Security Management System where data manipulation will be audited and signatures will be required to account for the data modification. Upon resource modification, the user will be required to enter a reason for change or select a predefined reason from a list. All data will be securely stored and maintained in the database and can be viewed using the reporting tool. This functionality will meet the general requirements of Validation and Compliance through Digital Signatures with special attention to the case of Title 21 CFR Part 11 Part B compliance.

14. Clean Room Solution:

- a. Overview: The Security Management System will provide a clean room solution which enables users to manage their “Clean Environments” or other areas requiring special restricted access through a process-oriented graphical user interface (GUI).
- b. Configuration: The user will have the capability of adding, editing, or deleting clean rooms. Each “clean room” will be capable of having a contamination level set. Entry to a higher level contamination area will automatically restrict access to cleaner level areas. Individual cards will be capable of being reset on an immediate one time, automatic, or per-hour basis.

- B. Network / Ethernet connectivity to be provided by Owner. This will include PoE Network Switches with designated ports for IP cameras, servers, and Ethernet controllers. This will also include required network routing to provide connectivity for complete system operation.

- C. Security Workstation / PC's: Owner to provide two (2) workstations with installed operating systems meeting the following minimum specifications. SMS Integrator / Installer will be responsible for connecting SMS monitors to both Owner provided workstations. SMS Integrator / Installer will also arrange for the installation of the SMS client software licenses by Owner's SMS Integrator of record.

1. Processor: Intel Core®2 Extreme 3.00 GHz, Quad Core 3.00 GHz/1333 MHz/12 MB
2. Memory: Minimum 4 GB of RAM
3. Hard Disk: Single separate hard drive or one RAID array utilizing 10K RPM SATA 150 GB or 10K-15K RPM SAS 146 GB
4. Secondary Storage: DVD-RW drive and a 3.5" 1.44 MB floppy disk drive
5. NIC: 1 Gigabit network interface card

6. Keyboard/Mouse: 12 function-keyboard and mouse
7. Graphics Adapter: Display adapter – Direct X 9 compatible 256 MB per monitor or greater
8. Video Card: Dual or quad video card
9. Operating System Options: Microsoft® Windows XP Professional SP2 (32-bit only) or Windows 7 Pro (32-bit and 64 bit)
10. Database: Microsoft SQL Express 2008 is automatically installed while installing MaxPro VMS Server
11. Monitor Resolution: 1280 x 1024 pixels, 65K color non-interlaced

## 2.3 OPERATIONAL REQUIREMENTS

### A. Door Hardware Interface:

1. Comply with requirements in Section 087100 "Door Hardware" and Section 087111 "Door Hardware (Descriptive Specification)" for door hardware required to be monitored or controlled by the access control system.
2. Electrical characteristics of controllers will match the signal and power requirements of door hardware.
3. All electronic door locking hardware and associated power supplies will be provided by others.
4. INTELLIGENT CONTROLLERS

- a. Distributed architecture will allow controllers to operate independently of the host. The architecture will place key access decisions, event/action processing and alarm monitoring functions within the controllers, eliminating degraded mode operation.
- b. Flash memory management will support firmware updates and revisions to be downloaded to the system. Upgrades to the hardware and software will occur seamlessly without the loss of database, configurations, or historical report data.
- c. Manufacturers: Subject to compliance with requirements, provide Field Controllers or comparable product by one of the following:

- 1) Honeywell Security PW-6000

### B. Security Management System Operational Requirements:

1. System Operations
  - a. Password: The Security Management System will use an integrated authentication method which utilizes Windows user accounts and policies.
  - b. Information Access: The Security Management System will be capable of limiting operator access to sensitive information. Operators must have proper authorization to edit the information.

- c. Shadow Login: The Security Management System will allow users to login over a currently logged-on user without having the current user log off the Security Management System or out of the Windows operating system.
- d. Graphical User Interface: The Security Management System will be fully compliant with Microsoft graphical user interface standards, with the look and feel of the software being that of a standard Windows application, including hardware tree-based system configuration.
- e. Help: The main Security Management System user interface will include a help icon which will require only one click to activate. The standard special function key "F1" will have the capability to be programmed to provide access to the help system.
- f. Guard Tour: The Security Management System will include a guard tour module, which will allow the users to program guard tours for their facility. The tours will not require the need for independent or dedicated readers.
- g. Secure Mode Verification (e.g., force guard to do a visual verify): The Security Management System will provide 'secure mode' control from the verification viewer. This will allow a user or guard to decide the access of an individual who presents his/her card at a designated secure mode reader.
- h. Database Partitioning: The Security Management System will support dynamic partitioning. A Security Management System in which partitions are set up at installation and cannot be easily changed will not be acceptable.
- i. Status Groups: The Security Management System will support a real-time system status monitor that graphically depicts all logical devices.
- j. Keyboard Accelerators: The Security Management System will allow the user to use a shortcut key to enable designated system commands.
- k. Automatically Disable Card upon Lack of Use: The Security Management System will allow system operators to set a predefined time period in which cardholders must swipe their card through a card reader in the Security Management System.
- l. User Functions and ADA Ability: The Security Management System will provide user functions and ADA (Americans with Disabilities Act) ability that provides the capability to trigger an event at the Security Management System intelligent controller when a defined card is presented.
- m. Pathways: The Security Management System will support the capability of programming pathways. A pathway will be an object that combines input points to be masked (shunted) for a set duration, and an output point to be activated, when a particular card receives a local grant at a reader.

- n. Database Audit Log: The Security Management System will be capable of creating an audit log in the history file following any change made to the Security Management System database by an operator.
  - o. Operator Log: The Security Management System will be capable of creating an action log in the history file following actions performed by an operator.
  - p. Alarm Routing: The Security Management System will be capable of defining routing groups that determine what event information will be routed to a user or class of users.
  - q. Global and Nested Anti-passback: The Security Management System will support the use of an optional anti-passback mode, in which cardholders are required to follow a proper in/out sequence within the assigned area.
  - r. Two Person Rule: The Security Management System will support a “two person rule” to restrict access to specific access areas unless two cardholders present two different valid cards to the reader one after the other within a period time defined by the door unlock time multiplied by a factor of 2.
  - s. Occupancy Restrictions: The Security Management System will allow the user to define the minimum and maximum occupancy allowed in a designated area.
  - t. Multiple Sequential Card Swipes to Initiate Procedure: The Security Management System will allow the user to define a logical device, quantity of consecutive identical events, a time period and a Security Management System procedure to trigger when the event occurs that quantity of times in the allocated time period.
  - u. Hardware Templates: The Security Management System will include the ability to define hardware templates (door templates) in order to simplify the process of creating an access control system. Hardware templates will allow a user to define a “typical” door configuration and then use that template over and over in the process of defining doors.
2. Access Control Functional Requirements: Functions will include validation based on time of day, day of week, holiday scheduling, site code verification, automatic or manual retrieval of cardholder photographs, and access validation based on positive verification of card/PIN, card, and video. The following features will be programmable and will be capable of being modified by a user with the proper authorization:
- a. Time Zones: Will define the period during which a reader, card, alarm point, door, or other system feature is active or inactive. In addition to Monday-Sunday, there will be at least one day of the week called Holiday.

- b. Holidays: The application will allow holidays to be entered into the Security Management System. Holidays will have a start date plus duration defining multiple days. Holidays will have a holiday type of 1, 2, or 3, which may be defined by the user.
- c. Response Codes: The Security Management System will allow the user to enter a predefined code to represent a response to an alarm occurring in the facility.
- d. Clearance Codes: The Security Management System will allow the user to establish groups of readers at a facility for the purpose of granting or denying access to badgeholders. Clearance codes will be assigned to companies and individuals employed by the company, and may be modified for individual users in the badgeholder maintenance application.
- e. Companies: Each badgeholder entered into the Security Management System will be assigned a company code identifying the individual's employer. The company information dialog box displays and maintains information related to companies having access to the facility.
- f. Group Access: The Security Management System will allow a user or group of users via company selection, a temporary denial of access to specific readers or areas based on a preconfigured event. The group access function will limit access to a group of cardholders, overriding all other access criteria.
- g. Events: The event editors will control processing done at the host computer that allows the user to associate nearly any input (trigger) with almost any sequence of outputs (actions) that the Security Management System is capable of executing.
- h. Alarm Pages: Security Management System will include the capability to create an unlimited number of customized alarm pages for the alarm monitor and each will be assignable to users and user classes.
- i. Event Types: Definitions will be shipped with system software but will be capable, upon installation, of being modified, added to, or deleted from the Security Management System.
- j. Dynamic Graphical Maps: The Security Management System will provide the user with the means to add maps and indicator icons to maps that will represent input/output points, logical devices, or cameras located throughout the Security Management System. Security Management System maps will display the state and condition of alarm points. The Security Management System will also provide the ability to monitor the channels or panels.
- k. Brass Keys: Will maintain information related to assets that are issued in the facility, including brass keys, laptops, RSA keys, cell phones, company cards, etc.
- l. ID Badging Client: The Security Management System Will maintain information related to a badgeholder's card access

privileges. Upon entering this application, a window will appear on the screen and all actions (add, modify, or delete) involving badges and cards will be initiated from this window. Access privileges will be linked to the cards used to gain access to doors in the facility. Modifications will be made by adding or deleting clearance codes, or by door types assigned to the cards or to a badgeholder.

- m. ID Badging System: The Security Management System will include seamlessly integrated ID badging system.
  - n. Users: Information related to the users of the Security Management System software will be stored in the database. Users entered into the Security Management System will be assigned the access privileges of the class to which they are assigned.
  - o. Generic Channel Interface: The Security Management System will provide the ability to define generic communications channels over serial port or TCP/IP network socket including IP address and port/socket, to support custom integration of external foreign devices. The Security Management System will generate events based on data received from the channel matching operator pre-defined instructions.
- 3. Application Localization: The Security Management System will support at least seven languages including English. The languages available must include German, French, Spanish, Italian, Chinese (simplified), Portuguese (Brazil), Norwegian, Chinese (Traditional), Danish, and Dutch. All database resources will be localized, and will include a standard U.S. English help file.
  - 4. Event Manager: The Security Management System will utilize an event manager as a component of system administration and offer the ability to have users control the amount of data stored as well as a quick snapshot of the logged data in the system. Using the various logs in event manager, the user will be able to gather information about events, auditing, and operator actions. The logs are defined as follows: Event log, audit log, unacknowledged alarms.

## 2.4 FIELD HARDWARE

- A. The security management system will be equipped with access control field hardware required to receive alarms and administer all access granted/denied decisions. All field hardware will meet relevant UL requirements.
- B. With integration to VMS, Security Management System will control multiple sources of video subsystems in a facility to collect, manage and present video in a clear and concise manner. VMS intelligently determines the capabilities of each subsystem across various sites, allowing video management of any analog or digital video device through a unified configuration and viewer. Disparate video systems are normalized and funneled through a common video experience. Drag

and drop cameras from the Security Management System hardware tree into VMS views. Leverage Security Management System alarm integration and advanced features such as pursuit that help the operator track a target through a set of sequential cameras with a single click to select a new central camera and surrounding camera views.

- C. Electronic Door Locking Hardware and Power Supply Controller: To be provided and installed by others. Power supply controller to include access control interface connections.
- D. Intelligent Controller Board(s)
  - 1. Honeywell Security PW6K1IC
- E. Dual Reader Module(s) (DRM)
  - 1. Honeywell Security PW6K1R2
- F. Alarm Input Module(s) (AIM)
  - 1. Honeywell Security PW6K1IN
- G. Relay Output Module(s) (ROM)
  - 1. Honeywell Security PW6K1OUT
- H. Card Reader(s)
  - 1. iClass RP40 SE Series, 13.56MHz Smart Card Reader and 125kHz, Single-gang Mount
  - 2. iClass RP15 SE Series, 13.56MHz Smart Card Reader and 125kHz, Mullion Mount
- I. Power Supply(ies)
  - 1. Honeywell Security PW6K2E2PS for each PW5K2ENC1
- J. Access Control Panel(s)
  - 1. Honeywell Security PW5K2ENC1
- K. Daisy Chain Cable(s)
  - 1. Honeywell Security PW5K1DCC for each PW5K2ENC1
- L. ProWatch Licenses:
  - 1. ProWatch CE 32-Reader License Add-on Module
  - 2. ProWatch CE Concurrent User License Add-on Module

- M. Request to Exit Motion Detectors: adjustable “tamper proof” shutters, two (2) form C outputs, and adjustable relay time (.05 to 64 seconds). Requires a trim-plate for each device.
- N. Access Control Door Position Switch: All access controlled doors will receive a door position switch to control door propped conditions. All access controlled perimeter doors must be DPDT and all access controlled interior doors must be SPST.
1. Gap distance (max) 9mm, connections 3 cm wire leads
- O. Honeywell MaxPro NVR PE specifications:
1. Database: Microsoft SQL Express 2008 R2
  2. Operating System: Windows 7 Embedded 64-bit, SP1
  3. Image Compression Supported: MPEG-4 and H.264
  4. Maximum Number of client connections: 18 per unit from 9 remote workstations
  5. Salvo layouts: Full, 2x2, 1x5, 3x3, 2x8, 1x12, 4x4
  6. Live settings per camera: constant, event based and user activated.
  7. Operators: 10
  8. Processor: Intel Core I7-3770, 3.4GHz
  9. Storage Capacities: 4 TB to 24 TB raw storage
  10. RAID Card: 6 GB/s SAS/SATA RAID Card, PCI Express x8, supports RAID levels up to 6+0
- P. Honeywell Enterprise VMS System:
1. (2) Quad-core Intel Xeon Processor x5550(2.66GHz, 8M Cache, 95 Watts, 1333MHz)
  2. (2) 4GB PC3-10600E 4x1GB Rank Memory
  3. (1) Microsoft Windows 2008 Server, Standard Edition 5 CALs (DVD Required) (Pre-Installed)
  4. (1) Embedded P410i (SAS Array Controller)
  5. (2) 146GB 6G Hot Plug 2.5 SAS Dual Port 15,000 rpm Hard Drive
  6. (2) 300GB Hot Plug 2.5 SAS Dual Port 10,000 rpm Hard Drive
  7. (1) RAID 1 drive set (requires a HP SA P410 or P411 Controller)
  8. (1) Slim 12.7mm SATA DVD\_RW Optical Drive
  9. (2) Embedded NC382i Dual Port Multifunction Gigabit Server Adapters
  10. (2) (2) 460W HE 12V Hotplug AC Power Supplies
  11. (1) ProLiant Foundation Pack Single Release Factory Integrated Software
  12. (1) Integrated lights out 2 (iLO 2) Standard Management
  13. (1) DL380 G6 Server
- Q. MaxPro VMS Licenses
1. (1) HNMPE32B243S – Honeywell MaxPro NVR PE Unit 32-Channels, 8GB RAM, 2x OS HD

2. (1) HNM64 – MaxPro License 64 Channel Add-on
3. (5) HNMSWCL – MaxPro Software Client License Add-on(s)

R. Cameras:

1. Indoor 1080p Fixed Position: Honeywell H4D2F1 1080p High Definition ONVIF IP Camera, Day/Night, Impact Resistant with H.264 compression and 3-9mm lens. Include appropriate mount for the application.
2. Outdoor 1080p Fixed Position: Honeywell HBD2FR1 1080p High Definition ONVIF IP Camera, Day/Night with 48 LED IR Illuminators, Impact Resistant with H.264 compression with 3-9mm or 10-23mm lens. Include appropriate mount for the application.

S. Camera Accessories to be installed on all light poles with cameras:

1. Pole mounted camera adapters
2. Local power supply will be installed on each light pole with a camera
3. Harden network switch (Fiber ST to CAT6) will be installed
4. Proper cable management inside all NEMA enclosures
  - a. NEMA enclosures to be provide and installed by others
5. Fiber Patch Panels (ST connectors)
6. 24-Port CAT6 Patch Panels

T. Monitors:

1. (2) KDL40BX450 Sony Bravia 40” HDTV monitor
2. (2) tilting wall mounts for 40” monitors
3. (2) SVGA connectors for monitors to workstations

U. Server Rack:

1. Server Rack (LER-4432)
  - a. Rack must be at least 32” deep
2. Front Door (fully vented) with key cylinder (LED-44FV)
3. Fan-Panel w/4 whisper style fans (FW4-7)
4. Fan Thermostat Controller (FTC-1)
  - a. Rack Rail Kit (RRD-21)
5. Wall mount rack will be provided Owner.

V. KVM: Rack mountable keyboard, video monitor and touch pad mouse, 19” LCD wide screen, 1440x900 resolution and 16:9 aspect ratio

- W. KVM Switch: 4-port switch, 4 x 50 pin centronics, network stack device: 2 x 25 pin D-Bub (DB-25), 1 xRJ11 – management.
- X. UPS:
  - 1. (2) Rack Mountable UPS (SMT1500RM2U)
- Y. Intercom Interface:
  - 1. Gate Interface: Provide and install two separate modules to interface with the main entrances gate and barrier-arm operator with the Honeywell ProWatch System. Provide 50 Wiegand output keyfobs with button for use from buses and other vehicles and will interface with both the gate and barrier-arm operator. Keyfobs must be programmed into ProWatch and use a unique numeric identification to each vehicle in which the keyfob is assigned to / installed. Provide a bi-level pedestal with a HID access card reader and intercom station on both levels. Include acrylic backplate for reader mounts on pedestal. These devices must be integrated with the main entrances gate and barrier-arm operator. Customize the programming and scheduling of the gate operators (opening/closing) of the gate and barrier-arm operator with the customer. Customize the programming of each credential and keyfob with the gate and barrier-arm operator with the customer.
  - 2. Automated Gate Operators: To be provided by others. Automated gate operators to included access control interface connections. The interface will provide access control gate opening initiation through the access control system.
  - 3. (2) Door / Gate Intercom Station: Audio only door station, red mushroom call button, stainless steel, vandal and weather resistant, flush mount
    - a. Back-Box: 2-gang box, vertical mounted to bi-level pedestal
  - 4. Master Intercom Station: Audio only 5-call master station, selective door release, surface mount
  - 5. Intercom Power Supply: 12v DC power supply
  - 6. Gate Release Module: 12V DC and relay contact rating of 24V DC, 1A or .03A @240V AC
  - 7. Dual Reader Module (DRM)
    - a. (2) Honeywell Security PW6K1R2
  - 8. Relay Output Module (ROM)
    - a. (1) Honeywell Security PW6K1OUT
  - 9. Hoffman Climate Controlled Enclosure with heater and blower to store the DRM's ROM, and required power supplies. Includes lightening protection for all devices and cabling housed in this enclosure

10. Keyfobs: (50) single button microplus PROXmitters w/HID tag.
11. RF Receiver: (2) MicroPLUS, high security encrypted rotating code, transmits codes to a Weigand controller in 26. 30 or 31-bit Weigand format.
12. Card Readers
  - a. iClass RP40 SE Series, 13.56MHz Smart Card Reader and 125kHz, Single-gang Mount
13. Pedestal: Bi-Level (Dual Height) pedestal with mounting back plates for single and double gang back-boxes.
- Z. Intrusion Detection Control Panel: Vista 128BPT, supports up to 119 additional zones using a built-in polling (V-Plex, multiplex) loop interface, ability to control eight (8) separate partitions independently, 150 user codes, and keeps a log of up to 512 events.
- AA. Intrusion Detection Keypad: (3) 6160, large, easy-to-use keypad, keys continuously backlit, (4) four programmable function keys.
- BB. Intrusion Detection Motion Detectors: (9) dual technology (heat and motion detection), wide angle lens, programmable levels
- CC. Intrusion Detection Siren: (2) Wave2 interior siren, 106db, dual tone siren output.
- DD. Intrusion Integration Module – four (4) programmable relays to selected Honeywell Vista panels and provides additional output capabilities
- EE. Intrusion Detection V-Plex: pooling loop addressable technology.
- FF. Intrusion V-Plex Adaptor – 4193SN micron-miniature two-zone V-Plex adapter, one supervised zone and one unsupervised zone, built-in serial number for addressing, UL listed fire and burglary.
- GG. Back-Boxes and Conduits: Will be provided and installed by the electrical contractor. All conduits will include a pull string. Refer to the special systems drawings for mounting heights and locations of back-boxes

## 2.5 WIRING

- A. Purple patch CAT6 cables
  1. Biscuit to Camera Patch Cables
  2. Fiber Patch Panel to Patch Panel – Patch Cables
  3. Patch Panel to Network Switches – Patch Cables
  4. Network Switches to DVR – Patch Cables
  5. CAT6 cable for all interior cameras and exterior cameras connected mounted to both buildings.

- B. Outdoor rated multi-mode 6 stranded fiber, 62.5 micron.
  - 1. Separate cable runs from the fiber patch panel in the building to each pole with a camera
  - 2. ST fiber tips
  - 3. All fiber pulled inside the buildings is required to be installed inside inner duct
  
- C. Access Control System:
  - 1. 6 conductor / 18 gauge wire to all card readers
  - 2. 4 conductor / 18 gauge wire to all electronic door locking hardware power supplies and gate operator integration modules
  - 3. 10 conductor / 22 gauge wire for all door position switches, request to exit motion, and spares of future device at each access controlled door location
  - 4. 2 conductor / 22 gauge wire for all access control panel to access control panel cabling
  
- D. Intrusion Detection System:
  - 1. 4 conductor / 18 gauge wire for V-Plex pooling loop, keypad and siren
  - 2. 4 conductor / 22 gauge wire for the 4193SN adaptor to the intrusion field device (door contact and motion detector)
  
- E. Integration Programming:
  - 1. Programming: provide custom programming of door schedules and individual credentials for each door of access control. Provide custom programming for the gate and barrier arm operators.
    - a. Intrusion Detection System to ProWatch
    - b. Intercom System to ProWatch
    - c. Gate Operators to ProWatch
    - d. Push Button Keyfobs to Gate Operators and ProWatch
    - e. MaxPro VMS to ProWatch

## 2.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
  - 1. Manufacturer's Field Service: Engage a manufactures service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
  
- B. Devices and circuits will be considered defective if they do not pass tests and inspections.

2.7 TRAINING

- A. Conduct on-site system administrator and security management systems training session with Owner and require sign-offs with Owners approval of the installation of all SMS.

**PART 3 - EXECUTION (NOT USED)**

**END OF SECTION**