

78

August 1, 2025 Letting

Notice to Bidders, Specifications and Proposal



**Illinois Department
of Transportation**

**Contract No. 76U37
MADISON County
Section DIST 8 PS 2025-1
Various Routes
District 8 Construction Funds**

Prepared by

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Checked by

(Printed by authority of the State of Illinois)



NOTICE TO BIDDERS

- 1. TIME AND PLACE OF OPENING BIDS.** Electronic bids are to be submitted to the electronic bidding system (iCX-Integrated Contractors Exchange). All bids must be submitted to the iCX system prior to 12:00 p.m. August 1, 2025 prevailing time at which time the bids will be publicly opened from the iCX SecureVault.
- 2. DESCRIPTION OF WORK.** The proposed improvement is identified and advertised for bids in the Invitation for Bids as:

**Contract No. 76U37
MADISON County
Section DIST 8 PS 2025-1
Various Routes
District 8 Construction Funds**

Pump repairs at the Bowman Pump Station in East St. Louis, Grey-s Pump Station in Pontoon Beach, Venice Pump Station in Venice, 9th Street Pump Station East St. Louis, and Centralia Pump Station in Centralia.

- 3. INSTRUCTIONS TO BIDDERS.** (a) This Notice, the invitation for bids, proposal and letter of award shall, together with all other documents in accordance with Article 101.09 of the Standard Specifications for Road and Bridge Construction, become part of the contract. Bidders are cautioned to read and examine carefully all documents, to make all required inspections, and to inquire or seek explanation of the same prior to submission of a bid.

(b) State law, and, if the work is to be paid wholly or in part with Federal-aid funds, Federal law requires the bidder to make various certifications as a part of the proposal and contract. By execution and submission of the proposal, the bidder makes the certification contained therein. A false or fraudulent certification shall, in addition to all other remedies provided by law, be a breach of contract and may result in termination of the contract.
- 4. AWARD CRITERIA AND REJECTION OF BIDS.** This contract will be awarded to the lowest responsive and responsible bidder considering conformity with the terms and conditions established by the Department in the rules, Invitation for Bids and contract documents. The issuance of plans and proposal forms for bidding based upon a prequalification rating shall not be the sole determinant of responsibility. The Department reserves the right to determine responsibility at the time of award, to reject any or all proposals, to readvertise the proposed improvement, and to waive technicalities.

By Order of the
Illinois Department of Transportation

Gia Biagi,
Secretary

VARIOUS ROUTES
SECTION DIST 8 PS 2025-1
MADISON, ST. CLAIR, AND MARION COUNTIES
CONTRACT NO. 76U37

INDEX
FOR
SUPPLEMENTAL SPECIFICATIONS
AND RECURRING SPECIAL PROVISIONS

Adopted January 1, 2025

This index contains a listing of SUPPLEMENTAL SPECIFICATIONS and frequently used RECURRING SPECIAL PROVISIONS.

ERRATA Standard Specifications for Road and Bridge Construction (Adopted 1-1-22) (Revised 1-1-25)

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VARIOUS ROUTES
SECTION DIST 8 PS 2025-1
MADISON, ST. CLAIR, AND MARION COUNTIES
CONTRACT NO. 76U37

RECURRING SPECIAL PROVISIONS

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STATE OF ILLINOIS

SPECIAL PROVISIONS

The following Special Provisions supplement the "Standard Specifications for Road and Bridge Construction," adopted January 1, 2022, the latest edition of the "Manual on Uniform Traffic Control Devices for Streets and Highways," and the "Manual of Test Procedures for Materials" in effect on the date of invitation for bids, and the Supplemental Specifications and Recurring Special Provisions indicated on the Check Sheet included herein which apply to and govern the construction of Various Routes, Section Dist 8 PS 2025-1, Madison, St. Clair, and Marion Counties, Contract No. 76U37, and in case of conflict with any part or parts of said Specifications, the said Special Provisions shall take precedence and shall govern.

Various Routes
Section Dist 8 PS 2025-1
Madison, St. Clair, and Marion Counties
Contract No. 76U37

LOCATION OF PROJECT

The project includes improvements to the existing 9th Street Pump Station along 9th Street. The project also includes improvements to four existing pump stations, including Venice Pump Station, Bowman Pump Station, Centralia Pump Station, and Grays Farm Pump Station. The locations of all the pump stations are shown on the cover of the drawings.

DESCRIPTION OF PROJECT

The 9th Street pump station consists of adding a new pre-cast concrete building at the site, relocation of electrical / controls equipment from an existing structure to the new pre-cast building, ventilation improvements within both the new pre-cast building and the existing structure for the 9th Street pump station, as well as the replacement of one storm water pump and refurbishing one of the existing storm water pumps. The other pump station improvements consist of ventilation improvements at each station by adding filtration equipment and making electrical modifications at each of the stations.

SUBMITTAL OF EEO/LABOR DOCUMENTATION

Effective: April 2016

This work shall be done in accordance with Check Sheets No. 1, 3 and 5 of the IDOT Supplemental Specifications and Recurring Special Provisions and the "Weekly DBE Trucking Reports (BDE)" special provision, except as here-in modified.

PAYROLL AND STATEMENT OF COMPLIANCE:

Certified payroll, (FORM SBE 48 OR AN APPROVED FACSIMILE) and the Statement of Compliance, (FORM SBE 348) shall be submitted by two methods:

1. By Mail (United States Postal Service): The ORIGINAL of the certified payroll and the Statement of Compliance for the Prime Contractor and each Subcontractor shall be submitted by mail to the Regional Engineer for District 8.
2. Electronically: Scan both the ORIGINAL of the certified payroll and the Statement of Compliance to the same PDF file and email to the District at the email address designated by the District EEO Officer.

SBE 48 and SBE 348 forms shall be submitted weekly and will be considered late if received after midnight seven business days after the payroll ending date.

WEEKLY DBE TRUCKING REPORT:

The Weekly DBE Trucking Report, (FORM SBE 723) shall be submitted electronically. Scan the form to a PDF file and email to the District at the email address designated by the District EEO Officer.

SBE 723 forms shall be submitted weekly and will be considered late if received after midnight ten business days following the reporting period.

MONTHLY LABOR SUMMARY & MONTHLY CONTRACT ACTIVITY REPORTS:

The Monthly Labor Summary Report (MLSR) shall be submitted by one of two methods:

1. For contractors having IDOT contracts valued in the aggregate at \$250,000 or less, the report may be typed or clearly handwritten using Form D8 PI0148. Submit the ORIGINAL report by mail to the Regional Engineer for District Eight. Contractors also have the option of using the method #2 outlined below.
2. For contractors having IDOT contracts valued in the aggregate at more than \$250,000, the report must be submitted in a specific "Fixed Length Comma Delimited ASCII Text File Format". This file shall be submitted by e-mail using specific file formatting criteria provided by the District EEO Officer. Contractors must submit a sample text file to District 8 for review at least 14 days prior to the start of construction.

The Monthly Contract Activity Report (MCAR) may be typed or clearly handwritten using Form D8 PI0149.

The MLSR and the MCAR shall be submitted concurrently. If the method of transmittal is method #1 above then both the MLSR and the MCAR shall be mailed together in the same envelope. If the method of transmittal is method #2 above then the MCAR shall be scanned to a .pdf file and attached to the email containing the MLSR .txt file.

The MLSR and MCAR must be submitted for each consecutive month, for the duration of the project, and will be considered late if received after midnight ten calendar days following the reporting period.

REQUEST FOR APPROVAL OF SUBCONTRACTOR:

The ORIGINAL and one copy of the Request for Approval of Subcontractor (FORM BC 260A) shall be submitted to the District at the IDOT Preconstruction Conference.

SUBSTANCE ABUSE PREVENTION PROGRAM CERTIFICATION:

The ORIGINAL and one copy of the Substance Abuse Prevention Program Certification (FORM BC 261) shall be submitted to the District at the IDOT Preconstruction Conference.

The Contractor is required to follow submittal procedures as provided by the EEO Officer at the preconstruction conference and to follow all revisions to those procedures as issued thereafter.

If a report is rejected, it is the Contractor's responsibility to make required adjustments and/or corrections and resubmit the report. Reports not submitted and accepted within the established timeframes will be considered late.

Disclosure of this information is necessary to accomplish the statutory purpose as outlined under 23CFR part 230 and 41CFR part 60.4 and the Illinois Human Rights Act. Disclosure of this information is REQUIRED. **Failure to comply with this special provision may result in the withholding of payments to the Contractor, and/or cancellation, termination, or suspension of the contract in whole or part.**

This special provision must be included in each subcontract agreement.

ALL HARD COPY FORMS TO BE SUBMITTED TO:

Region 5 Engineer
Illinois Department of Transportation
ATTN: EEO/LABOR OFFICE
1102 Eastport Plaza Drive
Collinsville, IL 62234-6198

Compliance with this special provision shall be included in the cost of the contract and no additional compensation will be allowed for any costs incurred.

STAGING AND SEQUENCE OF CONSTRUCTION

Construction Staging: The Contractor shall be responsible for and include all work for implementing and maintaining construction staging as may be required and as indicated on the drawings to maintain all existing pumping capabilities throughout the proposed work under this Contract and to complete all construction by the completion date specified in the contract document and as approved by the Engineer.

The Contractor shall confine its construction operations within the limits of existing pump station site (within the fenced area) at the 9th Street location. In the event the Contractor requires additional area or areas for its construction operations, it shall be responsible for leasing such

additional area or areas. No additional payment will be made for leasing additional area or areas. This expense shall be deemed as included in prices in the contract.

The Contractor shall prepare and submit to the Engineer for approval its proposed sequence of operations for the removal and relocation of the existing electrical equipment and installation of the new pump at the 9th Street location. Owner can shut off pumps at 9th Street for 8 hours for Contractor to complete the work. Should the Contractor require more than 8 hours to complete the work, Contractor shall provide temporary pumping. The shut down shall not be made if rain has occurred in St. Clair County during 72-hour period ending with planned start of the shutdown. The shut down shall also not be made if rain is predicted by National Weather Service for St. Clair County during 72-hour period beginning with planned shutdown. The submittal shall include all details and descriptions for the work under this Contract including, but not limited to protection of existing and new equipment; details for any temporary piping; reconstruction sequence; the proposed construction schedule indicating critical path the Contractor proposes to pursue on all work under this Contract; and all matters relating to this Contract. The submittal shall be a form acceptable to the Department and shall be subject to approval by the Department.

EXISTING UTILITIES

The Contractor shall familiarize themselves with the locations of all utilities and structures that may be found in the vicinity of the construction. As noted on the drawings, the drawings are based on existing plans provided by the owner. The Contractor shall confirm location of existing infrastructure and utilities. The Contractor shall conduct his operations to avoid damage to existing utilities and structures. Should any damage occur due to the Contractor's negligence, repairs shall be made by the Contractor at their expense in a manner acceptable to the Engineer.

TRAFFIC CONTROL PLAN

Effective: July 12, 1993

Revised: May 12, 1997

Traffic control shall be in accordance with the applicable sections of the "Standard Specifications for Road and Bridge Construction", the applicable guidelines contained in the "National Manual on Uniform Traffic Control Devices for Streets and Highways", Illinois Supplement to the National Manual of Uniform Traffic Control Devices, these special provisions, and any special details and highway standards contained herein and in the plans.

Special attention is called to Articles 107.09 and 107.14 of the "Standard Specifications for Road and Bridge Construction" and the following highway standards relating to traffic control:

701601 701901

In addition, the following special provision(s) will also govern traffic control for this project:

Short Term and Temporary Pavement Markings
Vehicle and Equipment Warning Lights
WorkZone Traffic Control Devices

REMOVAL AND DISPOSAL OF REGULATED SUBSTANCES

Description. This work shall consist of the removal and disposal of regulated substances according to Section 669 of the Standard Specifications as revised below.

Contract Specific Work Areas. For stationing, the lateral distance is measured from centerline and the farthest distance is the offset distance or construction limit, whichever is less.

The following contract specific work areas shall be monitored by the environmental firm for soil contamination and workers protection.

ISGS Site 4093-COV-12 – IDOT Pump Station Monitor 14, 1415 N. 9th Street, Fairmont City (NW Quadrant of Collinsville Rd and RR tracks), St. Clair County, Illinois

- All excavation associated with the installation of a new electrical building at the northwest quadrant of Collinsville Road and RR Tracks. The Engineer has determined this material meets the criteria of and shall be managed in accordance with Article 669.05(a)(5). Contaminants of concern sampling parameters include: VOCs, SVOCs, Metals, PCBs.
- A construction worker caution has been issued for this project due to the proximity to a SEMS site to the north of I-70.

Work Zones. Three distinct OSHA HAZWOPER work zones (exclusion, decontamination, and support) shall apply to projects adjacent to or within sites with documented leaking underground storage tank (LUST) incidents, or sites under management in accordance with the requirements of the Site Remediation Program (SRP), Resource Conservation and Recovery Act (RCRA), or Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), or as deemed necessary. For this project, the work zones apply for the following ISGS PESA Sites: **Site 4093-COV-12 (IDOT Pump Station Monitor 14)**

Additional information on the contract specific work areas listed above collected during the regulated substances due-diligence process is available through the District's Environmental Studies Unit (DESU).

NEW 9TH STREET PUMP STATION BUILDING

Description. This shall consist of all work for furnishing and installing the new pre-cast building at the 9th Street Pump Station site, including excavation, removal / disposal of unsuitable materials, foundation(s), and all building components. This also includes the site work for the project, including the fencing modifications, finished grading and the bollards. The building shall be a pre-cast concrete building structure in accordance with Section 504 (Precast Concrete Structures) of the Standard Specifications for Road and Bridge Construction.

Responsibility of Contractor. The Contractor shall take precautions to prevent damage to existing structures that will remain in place, while constructing the new pre-cast building. The Contractor shall be responsible for any damage or destruction of the existing facility resulting from neglect. Whenever damage occurs, the Contractor will restore the damage to a condition equal to that existing before any such damage or destruction was done.

Illinois State Law requires a 48-hour notice to be given to utilities before digging. The Contractor shall coordinate with all applicable facilities, prior to completing work.

Materials, Installation, and Coordination. See drawings, Section 504 (Precast Concrete Structures) of the Standard Specifications, and these special provisions.

Basis of Payment. The work for furnishing and installing the work for the new 9th Street pump Station Building and all applicable components, as shown on the plans will be paid for at the contract unit price per LUMP SUM for PRECAST PUMP STATION BUILDING.

ELECTRICAL EQUIPMENT RELOCATION

Description. This work shall consist of removing and relocating the existing electrical and controls equipment from the existing 9th Street Pump Station enclosure and relocating it to the New 9th Street Pump Station Building as shown on the drawings. The work also includes furnishing and installing the conduits (underground and above ground) and cable / wiring between the existing pump station enclosure and the New 9th Street Pump Station Building.

Materials, Installation, and Coordination. See plans and these special provisions.

Basis of Payment: The work for this item will be paid for at the contract unit price per LUMP SUM for PUMP STATION ELECTRICAL WORK.

NEW ELECTRICAL EQUIPMENT

Description. This work shall consist of furnishing and installing the new electrical equipment in the New 9th Street Pump Station Building as shown on the drawings. This work shall also consist of furnishing and installing the new electrical equipment in each of the four existing pump station buildings, as shown on the drawings.

Materials, Installation, and Coordination. See plans and these special provisions.

Basis of Payment. The work for this item will be paid for at the contract unit price per LUMP SUM for PUMP STATION ELECTRICAL WORK.

NEW CONTROL EQUIPMENT

Description. This work shall consist of furnishing and installing the new controls equipment and instrumentation equipment in the new 9th Street Pump Station Building, and in the existing pump station as shown on the drawings. The work also includes furnishing and installing the one replacement pump, as shown on the drawings, including start-up and testing services. The work also includes the refurbishment of the pump that is removed, including replacing pump bearings, pump seals, O-rings, pump impeller, and pump rotating and stationary wear rings. The existing pump power cable, grommet seals and washers shall be re-used.

Materials, Installation, and Coordination. See plans and these special provisions.

Basis of Payment. The work for this item will be paid for at the contract unit price per LUMP SUM for PUMP SCADA EQUIPMENT.

MECHANICAL, HVAC AND VENTILATION EQUIPMENT

Description. This work shall consist of furnishing and installing the new ventilation equipment in the existing 9th Street building and the new 9th Street Pump Station Building, as shown on the drawings. This work shall also consist of furnishing and installing the new ventilation equipment in each of the four existing pump station buildings, as shown on the drawings.

Materials, Installation, and Coordination. See plans and these special provisions.

Basis of Payment. Furnishing and Installing the work for this item will be paid for at the contract unit price per LUMP SUM for HEATING AND VENTILATION.

PRE-BID SITE INSPECTION

There will be an opportunity to visit the pump station sites with the Department Project Management team and the Engineer. Please contact Rich Barbee at the Department (Richard.Barbee@illinois.gov or 618-346-3273).

SUMMARY OF WORK

Summary

The Work of this Contract is generally described as furnishing and installing new 9th Street Building, removal and relocation of existing electrical equipment, and providing new mechanical, electric and controls equipment and ventilation improvements and electrical work at four existing pump stations.

Work By Others

Utilities: None.

Work on Site which will be, or has been executed prior to, or after, start of Work on this Contract and may be concurrent to this Contract, but is excluded from this Contract: None.

Work Sequence: Construct Work in accordance with following requirements to accommodate operation of existing facilities during construction period. Coordinate construction progress schedule and operations with Engineer and Owner. Owner reserves right to place facilities taken out of service by Contractor back into service on emergency basis upon notification to Contractor.

Bypassing of untreated or partially treated sewage to surface water of drainage courses is strictly prohibited during construction. In the event accidentally bypassing is caused by the Contractor's operations, the Owner shall immediately be entitled to employ others, at the Contractor's expense, to stop the bypassing without giving written notice to the Contractor.

Penalties imposed on the Owner as a result of any bypass caused by the actions of the Contractor, his employees, or subcontractors, shall be borne in full by the Contractor, including legal fees and other expenses to the Owner resulting directly or indirectly from the bypass.

Draining, Cleaning, and Dewatering of Tanks, Channels, Conduits and Piping. Unless specified otherwise, draining, cleaning, and dewatering of tanks, channels, conduits, piping, and other facilities and proper disposal of removed solids shall be performed by Contractor as required to complete Work. Unless specified otherwise, Owner will not drain, clean, and dewater facilities to enable Contractor to complete Work. Contractor shall maintain facilities clean and dry as required to complete Work, including control and temporary pumping of leakage from isolation facilities and water resulting from precipitation.

Stormwater and groundwater flow through the existing pump station must be maintained at all times except as specified below. Contractor shall plan, schedule, and coordinate Work such that degree of stormwater and groundwater flow during construction shall be equal to or exceed degree of stormwater and groundwater flow prior to construction.

Flow at the 9th Street pump station may be interrupted not more than twice for construction of new electrical and controls work. Interruptions shall not be made during months of March, April, May or June. Each interruption shall not exceed 8 hours. Contractor shall schedule interruptions. Interruptions shall not be made without Owner's permission.

Contractor's Use Of Premises: Conduct operations to ensure least inconvenience to Owner and operation of existing facility. Cooperate with Owner during construction operations to minimize conflict and to facilitate Owner's operations.

When keys to locked areas are needed to provide access to areas to perform Work, obtain from Owner. Return keys at end of the project.

Contractor shall discuss and coordinate with Owner and Engineer prior to removing equipment from service in order to complete Work. Owner will, at Owner's discretion, request equipment to be placed back into service if out of service equipment will cause adverse effects on plant operation.

Obtain and pay for use of additional storage or Work areas needed for operations at no additional cost to Owner.

Owner Furnished Materials Or Equipment

Owner will furnish the following materials or equipment:

1. None.

Contractor's Responsibilities: Designate delivery and installation dates for materials and equipment in construction progress schedule. Review Shop Drawings, product data, and samples. Submit to Owner a list of discrepancies or problems anticipated in use of material or equipment. Handle material and equipment at site, including unloading at site in accordance with manufacturer's instructions. Inspect material and equipment jointly with Owner, record shortages and damaged or defective items. Protect material and equipment from exposure to the elements, and from damage. Assemble, install, connect, adjust, finish, and test in accordance with manufacturer's written instructions and Contract Documents. Repair or replace items damaged by Contractor.

Owner Occupancy Of Premises: Owner will occupy site and existing facilities during entire construction period for conduct of normal operations.

Owner reserves right to partially occupy and to place and install equipment in completed areas of facilities, prior to Substantial Completion, provided that such occupancy does not interfere with completion of Work. Such placing of equipment and partial occupancy shall not constitute acceptance of the Work.

Submittals. Contractor to prepare and submit shut down plan to Owner and Engineer for review and approval a minimum of 45 days prior to conducting work. Submittal to include Contractor's proposed plan for each shut down (if any) including schedule / duration of each shut down, equipment to be taken out of service, list of backup equipment and supplies available during the shut down, list of personnel proposed to be on-site during the shut down, and list of personnel that can be available to be on-site if needed.

CLEANING AND WASTE MANAGEMENT

Summary: Perform cleaning throughout construction period and at completion of Work. Conduct cleaning and disposal operations to comply with codes, ordinances, regulations, and anti-pollution laws.

Cleaning Materials And Equipment: Use only the cleaning materials and equipment which are compatible with the surface being cleaned, as recommended by the manufacturer of the material. Use only those cleaning materials which will not create hazards to property and persons.

During Construction: Provide on-site containers for collection and removal of waste materials, debris, and rubbish in accordance with applicable regulations.

As required preparatory to installation of succeeding materials, clean the structures or pertinent portions thereof to the degree of cleanliness recommended by the manufacturer of the succeeding material, using equipment and materials required to achieve the necessary cleanliness.

Following the installation of finish floor materials, clean the finish floor daily (and more often if necessary) at all times while work is being performed in the space in which finish materials are installed.

Existing Pump Station Sump/Wet Well Cleaning. Contractor shall clean the existing sump/wet well at the 9th Street pump station, the Venice pump station and the Centralia pump station. Contractor shall be responsible for creating a safe, suitable work environment for cleaning each sump/wet well. Contractor shall provide all equipment, materials, personnel, and procedures necessary to clean each sump/wet well. Contractor is responsible for dewatering the existing sump/wet well to allow for cleaning. Contractor shall use vactor truck for cleaning and shall remove any floating materials from the sump/wet well. After the material in the sump/wet well has been removed, Contractor shall use a high-pressure wash on the walls of the existing sump/wet well structure. Contractor shall dispose of material in accordance with local and state regulations. At the completion of cleaning of each pump station sump/wet well, the Contractor shall coordinate to have Department inspect the sump/wet well. Contractor shall comply with all regulations of OSHA.

Final Cleaning: Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

Ventilating Systems: Clean permanent filters and replace disposable filters if units were operating during construction. Clean ducts, blowers, and coils if units were operated without filters during construction.

Electrical Systems: Leave electrical equipment rooms broom clean. Clean interior of panel cabinets, pull boxes, and other equipment enclosures. Clean lighting fixtures, lamps, and other electrical equipment soiled during installation.

Clean roads and streets used as haul roads during construction of accumulated material. Clean paved streets with water.

Prior to Final Completion or Owner occupancy, Contractor, with Engineer and Owner, shall conduct inspection of exposed interior and exterior surfaces and work areas to verify Work and Site is clean.

PROJECT RECORD DOCUMENTS

Summary: Throughout progress of the Work, maintain an accurate record of changes in the Contract Documents.

Maintain at Site one record copy of:

1. Drawings.
2. Project Manual.
3. Addenda.
4. Change Orders and other modifications to Contract.
5. Engineer Field Orders, written instructions, or clarifications.
6. Approved Shop Drawings and other Work-related submittals.
7. Field modifications made to equipment by Contractor, Subcontractors and Suppliers.

8. Field test records.
9. Construction photographs.
10. Associated permits.
11. Certificates of inspection and approvals.

Submittals. Prior to Substantial Completion, submit revised operation and maintenance data for field modifications made by Contractor, Subcontractors, and Suppliers.

Prior to Substantial Completion, submit revised copies of approved Shop Drawings and other Work-related submittals for equipment modified in field by Contractor, Subcontractors, and Suppliers.

Prior to submitting request for Substantial Completion, deliver one complete coordinated marked up set of Drawings to Engineer for use in preparation of record drawings.

Prior to submitting request for final payment, submit the remaining Project Record Documents to Engineer for Owner.

Accompany submittals with transmittal letter containing following:

1. Date.
2. Project title and number.
3. Contractor's name and address.
4. Title of record document.
5. Signature of Contractor or authorized representative.

Execution

Record Drawings. Maintain one record set of Drawings, in electronic PDF format (one PDF file for each drawing volume), legibly annotated to show all changes made during construction and the final location of all underground piping and utilities. The marked up set of Drawings shall be a compilation of all of the changes made by all of the trades involved. Individual sets from the various subcontractors will not be accepted. The marked up set of Drawings shall graphically show the changes. Reference to RFI's, Change Orders, Field Orders, etc. will not be accepted. The marked up set of Drawings shall incorporate changes made to the primary drawings and shall include the corresponding changes made to the ancillary drawings. Changes made to the process drawings, electrical drawings, and I&C drawings shall be depicted on the P&ID's.

All annotations on Record Drawings shall be done electronically in PDF format. The base drawing used for Record Drawing edits shall be in an original PDF file. Using the following color scheme:

- a. RED: For drawing additions or elements to be added to the drawing.
- b. GREEN: For items to be removed or deleted from the drawing.
- c. BLUE: For descriptive notes, dimensions, arrows, or other labels to provide direction to drafters but that are not specifically intended to be added to the drawings.

Coloring scheme, labels, dimensions, and line work shall be consistent throughout the entire Record Drawing set. Use a straight-line drawing tool where appropriate. Use text boxes with appropriately sized text for all text work. All drawing comments shall be "flattened" prior to submitting any Record Drawings to prevent the inadvertent shifting or changing of any comment or mark-up and to provide final documentation of all mark-ups.

Record information concurrently with construction progress.

Drawings: Graphically depict changes by modifying or adding to plans, details, sections, elevations, or schedules. Note the following:

- a. Depths of various elements of foundation in relation to finished first floor elevation.
- b. Horizontal and vertical locations of underground cable, conduit, duct runs, underground utilities and appurtenances, and underground piping referenced to visible and accessible features. These features shall be located where they leave or enter any structure and at changes in horizontal or vertical direction. The invert elevation of piping and the top of conduit or duct banks shall be noted. GPS coordinates may be used.
- c. Field changes.
- d. Details not on original Drawings.
- e. Location and identification of exposed interior piping, including those shown schematically on Drawings.
- f. Location and size of equipment including connections.
- g. Departures from original Drawings.

Record Specifications. Mark Specification sections to show substantial variations in actual Work performed from that indicated in Specifications and modifications to Specifications. Give particular attention to substitutions, selection of options and similar information on elements that are concealed or cannot otherwise be readily discerned later by direct observation. Note related record drawing information and product data.

SYSTEMS DEMONSTRATIONS

Description. Before Substantial Completion is considered, Contractor shall demonstrate satisfactory operation of specific equipment systems and associated facilities. Prior to conducting system demonstrations, the Contractor shall prepare a start-up plan unique to each system. Conduct demonstrations on systems listed below. Each system shall include facilities listed and associated structures, channels, conduits, piping, valves, gates, electrical, instrumentation, water, and other utilities necessary for system operation.

1. System 1 – Electrical, Pump and Controls Equipment – 9th Street Pump Station
 - Equipment shown Drawing No. 009-N-1, 500-EN-1 through 500-E-4.
2. System 2 – Ventilation Equipment – Venice Pump Station
 - Equipment shown Drawing No. 100-SHE-1.
3. System 3 – Ventilation Equipment – Bowman Pump Station
 - Equipment shown Drawing No. 200-H-1 and 200-H-2.
4. System 4 – Ventilation Equipment – Centralia Pump Station
 - Equipment shown Drawing No. 300-HE-1.
5. System 5 – Ventilation Equipment – Grays Farm Pump Station
 - Equipment shown Drawing No. 400-SHE-1, and 400-H-2.

Preliminary: Before Contractor begins Systems Demonstrations, the following Work shall be complete:

- Operation and maintenance (O&M) data has been submitted to and approved by Engineer.

- Process control system testing as specified in Section 40 61 21.
- Substantial Completion of building, HVAC, electrical, and building lighting.

Contractor shall provide services of qualified, certified representatives of Suppliers to be present at Project Site as necessary to successfully complete Systems Demonstrations.

Coordination: Designate representative of Contractor to be responsible for Systems Demonstrations. Notify Engineer at least 7 days before Systems Demonstrations are to begin. Reschedule cancelled Systems Demonstrations 7 days in advance.

Submittals

Start-up Plans. For each System identified in Paragraph 1.01.A above, Contractor shall prepare a system specific start-up plan. Submit each start-up plan no later than 2 weeks prior to the start date of each System's demonstration test. Each system's start-up plan shall include a detailed step-by-step procedure addressing the requirements of this Section. Each plan shall identify the required activities that need to be completed, who will be responsible for completing each activity, the order in which the activities need to be completed, and a schedule giving the dates for each activity. Each start-up plan shall describe the documentation that needs to be prepared to confirm that the activities have been successfully completed. Each start-up plan shall identify the Contractor's representative that will be leading the Systems Demonstration.

Reports: Prepare report for each system on results and activities encompassing system demonstration. Submit report within two working days of completion of System Demonstration. Report shall describe operational conditions; daily results of systems operation; dates and names of people involved and observing operation; and statement regarding system ability to meet operational criteria.

Systems Demonstrations. Demonstrate operation and performance of each system.

1. Where no specific performance requirements are stated in Specifications, demonstrate to show equipment operates in accordance with acceptable industry standards for application of equipment.
2. System Demonstration shall show equipment operates within manufacturer's tolerances for noise and vibration, equipment is responsive to manual and automatic controls, control and protective devices are properly set, and equipment operates on controlled or intermittent basis when such operation is intended.
3. Demonstrate proper function and process control for each control point, alarm, and safety lockout system.

Temporary facilities and services are Contractor's responsibility. Contractor shall provide temporary facilities and services as required to complete testing and systems demonstrations. Contractor shall also provide required equipment maintenance during the time between the systems demonstration testing and the issuance of a Certificate of Substantial Completion.

For each system, Engineer will consider system demonstration successful and complete when system operates properly without significant interruption.

If, in Engineer's opinion, system is not operating properly at any time during System Demonstration, Contractor shall stop demonstration and adjust, calibrate, or replace material and

equipment as required to correct problem. After corrections have been made, restart System Demonstration and operate system without significant interruption.

If the system is not operating properly, and the Contractor opts to continue operating the system until the corrections to the system have been completed and the system can proceed to restarting the Systems Demonstration, the Contractor shall continue to be responsible for providing ongoing required equipment maintenance, temporary facilities and services.

Substantial Completion. Engineer will not consider Work substantially complete until Systems Demonstrations have been successfully completed.

PRECAST CONCRETE

Summary. Provide precast prestressed concrete roof members and wall panels where shown on the Drawings, as specified herein, and as needed for a complete and proper installation.

References

- ACI: American Concrete Institute
- PCI: Precast Concrete Institute
- ASCE: American Society of Civil Engineers

System Description. Precast manufacturer shall be responsible for structural design of individual precast prestressed components and connections between components to form complete structure.

Design, reinforce, and prestress units as required by ACI 318, PCI Design Handbook, local building code, and as specified herein.

Design and provide members capable of supporting superimposed loads shown on Drawings including following:

- Roof Live Load: As noted on the drawings.
- Roof Snow Load: As noted on the drawings, minimum loads per ASCE 7.
- Roof mounted mechanical equipment and piping.
- Dead Load: Weight of the structure plus additional loads as noted on drawings.
- Wind Load: As noted on drawings, minimum loads per ASCE 7.
- Seismic Load: As shown on drawings, minimum loads per ASCE 7.
- Load combinations in accordance with ASCE 7 or ACI 318.

Provide 1-1/2 hour UL fire resistance rated units unless otherwise noted.

Roof plank shall be hollow core Machine Cast (Dry Cast) units.

Wall panels shall be sandwich panels constructed of a wet cast or hollow core dry cast inner wythe, rigid insulation, and a non-composite fiber reinforced outer wythe.

Conform to the shapes indicated.

Submittals

Shop Drawings:

1. Content:
 - Dimensions.
 - Design loads.
 - Design camber.
 - Fabrication details.
 - Details of inserts, anchors, connections, accessories, joints, and openings.
 - Chamfer and radius of corners.
 - Reinforcement and tendons.
 - Welds.
 - Finishes.
 - Lifting positions and devices.
2. Erection drawings including piece numbers and table referencing piece numbers to standard unit designations.
3. Stamped by Structural Engineer registered in State of Illinois.

Product Data:

- Catalog or table information for standard precast units.
- Sandwich panel insulation.

Miscellaneous Submittals: Evidence of certification or experience qualifications, when requested by Engineer.

Quality Assurance. Conduct testing in accordance with PCI MNL-116.

Shop Inspection: Shop inspection may be required by Owner at Owner's expense. Contractor shall give min 7 days notice to Engineer prior to starting fabrication and shipment of completed components so inspection may be provided. Shop inspection intended as means of facilitating Work and avoiding errors, but will in no way relieve Contractor from responsibility for furnishing proper materials and workmanship required by these Specifications.

Delivery, Storage, And Handling. Follow manufacturer's written instructions for handling and storage. Store units at the job site in a manner to prevent cracking, distortion, warping, staining, and other physical damage, and in a manner to keep markings visible. Lift and support the units only at designated lifting points or supporting points as shown on the approved Shop Drawings.

Manufacturers. Firms specializing in providing precast prestressed concrete products and services normally associated with industry for at least 3 yrs. Manufacturers meeting requirements of PCI MNL-116. Manufacturers may be required to submit written evidence showing experience, qualifications, and adequacy of plant, facilities, and ability to perform Work.

Materials

Portland Cement: ASTM C150, Type I, II, or III.

Blended Hydraulic Cement: ASTM C595, Type IL, IP, or IS.

Fly Ash:

1. ASTM C618, Class C or F including requirements of Table 1A.
2. Supplemental Requirements:
 - a. Loss on Ignition (maximum): 3%.
 - b. Water Requirement (maximum): 100% (as percent of control).
 - c. Fineness (maximum retained on No. 325 sieve): 25%.

Slag Cement: Slag cement shall conform to the requirements of ASTM C989 Grade 100 or 120. Slag cement from different sources or of different grades shall not be mixed in the same construction.

Admixtures:

- Air-Entraining: ASTM C260.
- Chemical: ASTM C494, non-corrosive and chloride free.

Aggregates:

- ASTM C33.
- Natural materials.
- Maximum 3/4 inch.

Water: Potable.

Reinforcing Steel:

- Deformed Steel Bars: ASTM A615, Grade 60.
- Welded Wire Fabric: ASTM A185.
- Fabricated Steel Bar Mats: ASTM A184.

Fiber Reinforcement:

- Manufacturers:
 - W.R. Grace & Co.
 - Fibermesh Co.
 - Euclid Chemical Co.
- 1/2 inch to 3/4 inch collated fibrillated virgin polypropylene fibers.
- ASTM C1116 Type III.

Tendons: Uncoated, stress-relieved strand, ASTM A416, Grade 250K or 270K. Low relaxation strand conforming to Supplement 1 may be used.

Anchors and Inserts:

- ASTM A36 or ASTM F1554, Grade 36. Manufacturer's standard primer.
- 304 stainless steel bolts.
- Types as indicated on the Drawings or as approved by Engineer.

Cement Grout: One part Portland cement and 3 parts sand.

Bearing Pads:

- Hollow Core Plank: 1/8 inch thick tempered hardboard or high-density plastic.

Welded Studs: AWS D1.1.

Sandwich Panel Insulation:

- Extruded polystyrene or polyisocyanurate.
- Minimum R value 5.00 per inch.
- Thickness as required to meet wall insulation values noted on drawings. Minimum 2 inches thickness required.

Joint Sealants and Accessories: Conform to requirements of Section 07 92 00.

Mix Design. Mix design shall be in accordance with manufacturer's recommendations.

Concrete Properties: Air-Entrainment for exterior wythe of sandwich panels, screen walls, and wet cast units:

- a. 19±3% in sand mortar as tested in accordance with ASTM C185.
- b. 7±2% in concrete as tested in accordance with ASTM C231.

28-Day Compressive Strength: Minimum 4000 pounds per square inch for hollow core plank.

- Absorption: 5% maximum.
- Fiber reinforce exterior wythe of wall panels.

Fabrication

Formwork: Construct forms to maintain units within specified tolerances with radius or chamfer corners. Locate lifting devices to not harm appearance of unit in finished position. Form treatments or curing compounds shall not contain ingredients which might stain concrete or reduce bond with subsequent coatings, finishes, etc.

Reinforcement:

- Pretension tendons in accordance with PCI MNL-116.
- Provide reinforcement necessary to resist applied loads, handling and erection.

Locate lifting devices to not harm appearance of unit in finished position.

Accurately and rigidly position embedded items during concrete placement. Avoid contact of dissimilar metals.

Batch, mix, and handle concrete in accordance with ACI and PCI recommendations.

Cure units in accordance with PCI MNL-116.

Detensioning:

- Detension units after concrete has reached release strength in accordance with design.
- If heat cured, perform detensioning while unit is still warm.
- Detension tendons in gradual sequence to prevent shock and unbalanced loads.

Finishes:

- Unexposed Areas: As cast.
- Exposed Faces of Wet-Cast Units:

- PCI Grade B finish.
- Surfaces concealed by materials other than paint: PCI Commercial finish.
- Interior Exposed Faces of Roof Plank and Wall Panels (Dry Cast Units):
 - Cast against concrete or steel casting beds maintained in accordance with industry practice.
 - Surface holes, chips, and spalls shall not exceed 1/4 inch.
 - Casting bed offsets and finish shall not exceed 1/8 inch.
- Exterior Faces of Wall Panels:
 - Form liner finish with brick pattern to match 25th street pump station (coordinate with Owner).
 - Exterior wythe of wall panels shall be colored concrete. Color to match exterior wall surfaces of 25th street pump station (coordinate with Owner).
 - Exposed face to match approved sample.
- Permanently exposed surfaces shall be consistent in appearance over entire area. Spotty coloring not accepted.

Fabrication tolerances shall conform to requirements of PCI MNL-116. Edges of units shall be true and parallel and not vary from a straight line more than 1/8 inch at any point. Edges shall be parallel within maximum variation of 1/8 inch at any point. Faces shall not vary from flat plane more than 1/8 inch at any point. Maximum warpage prior to installation shall not exceed that which can be corrected during installation.

Anchors, Holes, And Framing. Provide pipes, sleeves, inserts, weld plates, anchor plates, anchor bolts, bolts, concrete anchors, and other embedded items shown and as required. Place dissimilar metals to avoid physical contact between them.

Furnish inserts, plates, fastening devices, and anchors to be set in supporting structure.

Provide anchor straps, plates, angles, bolts, and other items as required to connect individual members to each other and supporting structure.

Holes shall be formed during manufacture of units, or field cut or cored. Location shall be coordinated with manufacturer. Do not cut tendons without manufacturer's consent. Over cutting will not be allowed. Edges of holes shall be neat and square, spalled edges will not be allowed.

Large Openings:

- Design and provide steel headers.
- Reinforce units adjacent to units with large openings to support additional dead and live load caused by opening.

At holes and along cut edges of hollow core units, exposed cores shall be grouted solid within 6 inches of hole or cut edge.

Source Quality Control. Comply with applicable requirements of PCI MNL-116. Make one compression test and absorption test for each day's production of each type of member. Test cylinders and absorption specimens shall be cast from the same materials and by the same methods as the precast units, and shall be cured in the same manner as the precast units. Compression test shall conform to ASTM C39. Absorption test specimen shall be tested at 28 days. Absorption test shall conform to ASTM C97.

Failure of any member to come within tolerances specified herein shall be cause for rejection.

Surface Conditions. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

Installation

- A. Erect units in accordance with manufacturer's written instructions.
- B. Do not bear units on cast-in-place concrete construction until support has reached 80% of design strength.
- C. Provide bearing pads set on level and uniform bearing surfaces.
- D. Do not place warped, cracked, or broken units.
- E. Ends of units may be saw cut if required for proper clearance. Do not break units with hammer to produce proper clearance.
- F. Set units straight, level, plumb, and square.
- G. Set wall panels in bed of grout.
- H. Provide temporary supports and bracing as required to maintain position, stability, and alignment until units are permanently connected.
- I. Perform welding in accordance with AWS D1.1 and AWS D1.4.
- J. Remove lifting devices and grout flush with adjacent surface.
- K. Repair damaged surfaces to match adjacent surfaces.
- L. Connect and anchor units to each other and other structural elements as shown and in accordance with approved shop drawings.
- M. Anchor hollow core units to supporting members as shown. When approved by Engineer, anchors may be drilled and grouted into supporting structure.
- N. Erection Tolerances:
 1. Floor and Roof Plank:
 - a. Alignment between units and along other structural elements: Maximum 1/8 inch per 10 feet, vertical and horizontal.
 - b. Elevation between adjacent roof or floor members: Maximum difference 3/4 inch at any point.
 - c. Gaps between adjacent roof or floor units: Maximum 1/4 inch.
 2. Wall Panels:
 - a. Top elevation: $\square$ 1/2 inch.
 - b. Bottom elevation: $\square$ 1/2 inch.
 - c. Plumb variation: $\square$ 1/4 inch per 10 feet. Maximum 1 inch.
 - d. Jog in alignment at bottom and top: $\square$ 1/2 inch.
 - e. Joint width: $\square$ 3/8 inch.
 - f. Jog in face alignment: $\square$ 1/2 inch.
 - g. Jog in reveal alignment: $\square$ 1/4 inch.
 - h. Differential bowing: $\square$ 1/2 inch.
 - i. Bowing @ corners: $\square$ 1/2 inch.

Grouting, Pointing, And Caulking

Floor and Roof Units: Grout joints between hollow core floor and roof units from top of unit, and finish on underside before hardening as follows:

- Where units to be exposed or painted as finished ceiling: Rake joints 1/2 inch deep and fill with sealant, finish smooth.
- Unexposed areas and areas with suspended ceilings: Rough formed or rough broomed.

- Trowel top of grout joints on roofs smooth to prevent unevenness interfering with placing of, or causing damage to, insulation or roofing. Slope due to differential elevations shall not exceed 1:12.

Wall Panels: Shim and grout horizontal joints of wall panels. Rake joints 3/4 inch deep, install backer rod and fill with sealant on interior and exterior exposed faces, finish smooth. Install backer rod and fill with sealant on interior and exterior faces of vertical joints, finish smooth. Provide fire-stopping material in vertical joints of fire rated walls.

Cleaning. Clean exposed surfaces with water, rinse thoroughly.

MAINTENANCE OF MASONRY

Summary. This Section includes repairing existing masonry, cleaning existing masonry, and tuck-pointing existing masonry where shown on the Drawings, as specified herein, and as needed for a complete and proper installation.

References

- A. ASTM: American Society for Testing and Materials

Submittals

- A. Product Data:
 - 1. Manufacturer's technical data.
 - 2. Recommendations for use and application.
 - 3. Test reports and certifications that products comply with requirements.

Quality Assurance. Work shall be performed by company having not less than 5 years experience in comparable masonry restoration and employing personnel skilled in the work indicated.

Prior to start of work of this Section; prepare sample panels in existing wall for each type of restoration work required.

- Minimum 4 feet long by 4 feet high panels showing:
 - a. Color range.
 - b. Texture range.
 - c. Bonding.
 - d. Method of removing mortar.
 - e. Mortar color.
 - f. Tooled joints.
 - g. Cleaning methods and results.
 - h. Quality of workmanship.

Do not start Work until Engineer has accepted sample panels. Use panels as standard of comparison. Failure of restoration work to meet or exceed quality of work depicted by sample panels shall be cause for rejection. Retain sample panels in undisturbed condition until Work completed and accepted by Owner.

Project/Site Conditions. Protect persons, motor vehicles, surrounding surfaces, surrounding buildings, and site from injury resulting from masonry restoration work. Clean masonry surfaces

only when air temperatures are 40°F and above and will remain so not less than 7 days after completion of cleaning. Do not repoint mortar joints or repair masonry unless air temperatures are between 40°F and 80°F and will remain so not less than 48 hours after completion of work. Make arrangements for collecting dust to ensure that it is confined to the immediate work area and does not spread outside of the immediate work area.

Materials

Mortar

- A. Materials:
 - 1. Portland cement: ASTM C150, Type I or II, white, non-staining.
 - 2. Blended cement: ASTM C595, Type IL, IS or IP, white, non-staining.
 - 3. Lime: ASTM C207, Type S.
 - 4. Aggregate:
 - a. Clean, rounded or natural salt-free sand, well graded, free from injurious amounts of dust, lumps, shale, alkali, surface coatings, and organic matter, and complying with ASTM C144.
 - b. Match the existing aggregate as closely as possible to provide color match without use of other additives.
 - 5. Do not use admixtures unless specifically approved by Engineer.
 - 6. Water: Potable.
 - 7. Mortar color pigment:
 - a. High purity, chemically inert, unfading, alkali-fast mineral oxides, finely ground, concentrated, mortar color pigments in color selected by Engineer.
 - b. Match the existing mortar color as closely as practicable.
- B. Mixing:
 - 1. Mix in accordance with the cement and color manufacturer's recommendations and conforming to ASTM C270.
 - 2. Prepare a sample of the proposed mix and allow it to cure.
 - a. Break open the sample and compare to the broken surface of the existing mortar.
 - b. Adjust the mix as required to exactly match the existing mortar in color and texture.
 - c. Retain the approved sample for use as a standard for mortar quality to be provided for the Work.

Brick_ Provide face brick and accessories, including lintel units, arches, corners, and other special shapes required to complete the work. Bricks shall match the existing in color, texture, and dimensions to the approval of Engineer. Conform to ASTM C216, Grade SW, Type FBX.

Cleaning_Materials

- A. Water: Potable.
- B. Brushes: Fiber bristle only.
- C. Acidic Cleaner:
 - 1. Manufacturers:
 - a. Sure Klean Restoration Cleaner or equal.

2. Manufacturer's standard strength acidic masonry restoration cleaner composed of hydrofluoric acid blended with other acids and combined with a special wetting system and inhibitors.

D. Limestone Cleaner:

1. Manufacturers:
 - a. Sure Klean Limestone Prewash and Afterwash or equal.
2. Manufacturer's standard 2-part system consisting of an alkaline cleaner for prewash and an acidic cleaner for afterwash.

E. Liquid Strippable Masking Agent:

1. Manufacturers:
 - a. Sure Klean Acid Stop or equal.
2. Manufacturer's standard liquid, film forming, strippable masking material for protecting wood, glass, metal, and polished stone surfaces.

Reinforcement And Anchors

A. Horizontal Joint Reinforcement:

1. Truss, Ladur, Ladur Tri-Rod, CRT, Dur-o-Tab, adjustable CRT, adjustable Dur-o-Tab by Dur-O-Wall, Inc.
2. 2 or 3 longitudinal 9 gauge galvanized rods welded to 9 gauge cross rods at 16 inches on center conforming to ASTM A82.
3. Provide special manufactured corner and wall intersection pieces.
4. Zinc coated.
 - a. Interior walls: ASTM A641, Class I.
 - b. Exterior walls: ASTM A153, Class B2.

B. Dovetail Anchor Slots and Anchors:

1. 20 gauge galvanized dovetail foam filled anchor slots compatible with anchors.
2. 16 gauge by 1 inch galvanized corrugated, dovetailed metal anchor straps. Where heavy duty anchors are called for, provide 3/16 inch thick anchor straps.
3. Zinc coated in accordance with ASTM A153, Class B2.

Other Materials. Provide other materials, not specifically described but required for a complete and proper installation, as selected by the Contractor subject to approval of Engineer.

Execution

Surface Conditions. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected. Inspect all existing masonry with Engineer to determine areas of existing masonry to be repaired.

Masonry Repair

A. Removal:

1. Remove damaged, spalled, or deteriorated brick by hand where indicated. Cut out full units from joint to joint in a manner permitting replacement of new full units.
2. Support and protect masonry to remain.
3. Salvage whole undamaged brick.

4. Clean edges of remaining masonry by removing mortar, dust, and loose debris.

B. Replacement:

1. Install new or salvaged brick. Fit replacement brick into bonding and coursing pattern of existing. Maintain joint width to match existing.
2. Lay replacement brick with full bed, head, and collar joints.
3. Brick which have an initial rate of absorption (suction) greater than 30 grams per 30 square per inch minimum as measured in accordance with ASTM C67, shall be wetted prior to laying. Use wetting method which will assure each unit is nearly saturated but surface dry when laid.
4. Tool joints to match existing.

Cleaning. Apply chemical cleaners in accordance with manufacturer's recommendations using brush or spray. Do not allow cleaners to remain on surfaces for periods longer than recommended by manufacturer. Prewet, apply cleaner, then rinse. For spray application, apply at pressures not exceeding 50 pounds per square inch. Do not apply cleaners to the same surface more than twice. If additional cleaning is required, use steam wash.

Tuckpointing

A. Routing Joints:

1. Use extreme care in removing existing mortar, avoiding damage to the existing masonry units.
2. Removal:
 - a. Remove existing mortar from joint to a depth 2-1/2 times the joint width or 1 inch whichever is greater, using hammer and cold chisel or other appropriate hand tools as approved by Engineer.
 - b. Do not use power tools unless it is demonstrated to Engineer's approval that masonry surfaces will not be damaged.
3. Using low pressure compressed air or a hose stream under normal pressure, thoroughly remove all loose material from joints and cracks.
4. Take care to avoid damaging existing brick or enlarging width of joints.
5. Remove damaged brick and replace with new brick of the type approved.

- B. Pointing: Rinse joint surfaces with water to remove dust and debris. Time application so at time of pointing, excess water has evaporated, and the joint surface is damp but free of standing water. Fill mortar joints in layers not more than 3/8 inch thick. Apply each layer with pressure as soon as previous layer has partially dried. Do not tool each layer smooth but leave surface of the layer rough to enhance bonding of subsequent layers. Compress the final layer as much as possible to completely fill the joint. Compact joints solidly before final tooling.

- C. Tooling: Tool joints to match existing work. Do not spread mortar over brick or other exposed surfaces. Do not featheredge mortar. Where joints are exposed to weather, tool such joints and make them smooth, solid, and watertight. Perform final tooling when mortar is thumb-print hard, tooling the joints to exactly match the historic tooling.

Cleaning. Clean the face of the masonry one to two hours after mortar has set. Use plain stiff bristle brush. If mortar has become too hard, use brush and plain water, augmented by use of wooden paddle or (only if necessary) a chisel. If harsher cleaning methods are required, allow mortar to cure 30 days before commencing.

CONCRETE UNIT MASONRY

Summary. Provide concrete unit masonry where shown on the Drawings, as specified herein, and as needed for a complete and proper installation.

References

- A. ASTM: American Society for Testing and Materials
- B. ACI: American Concrete Institute

Submittals

Shop Drawings:

- 1. Source, material certificates, and proportions by weight of cement, fine and coarse aggregates, and admixtures for mortar and masonry grout.
- 2. Bar reinforcement shop drawings.

Product Data:

- 1. Exterior masonry sealer manufacturer's literature.
- 2. Weephole manufacturer's literature.

Miscellaneous Submittals:

- 1. Material certification for masonry units. Test data shall not be more than 5 years old.
- 2. Certification of masonry compressive strength.

Delivery, Storage, And Handling. Store masonry units above ground on level platforms which allow air circulation under the stacked units. Cover and protect against wetting prior to use. Deliver decorative units packaged in manner to prevent damage.

Project / Site Conditions

A. Cold Weather Protection:

- 1. Temperature of masonry units shall not be less than 32°F when laid.
- 2. When air temperature falls below 40°F or when temperature of masonry units is below 40°F:
 - a. Remove visible ice on masonry units before unit is laid.
 - b. Heat mortar sand or mixing water to produce mortar temperature between 40°F and 120°F.
 - c. When air temperature is between 25°F and 40°F, completely cover masonry by covering with weather resistant membrane for 24 hours after construction.
 - d. When air temperature is between 20°F and 25°F, use heat sources, install wind breaks when wind velocity exceeds 15 miles per hour, and completely cover masonry with insulating blankets for 24 hours after construction.
 - e. When air temperature is below 20°F, provide enclosure and use heat source to maintain temperature within enclosure above 32°F for 24 hours after construction.

B. Hot Weather Protection:

1. When air temperature exceeds 100°F, or 90°F with wind velocity greater than 8 miles per hour:
 - a. Do not spread mortar more than 4 feet ahead of masonry.
 - b. Set units within 1 minute of spreading mortar.

Products

Mortar And Grout

A. Materials:

1. Portland Cement: ASTM C150, Type I.
2. Blended Cement: ASTM C595, Type IL, IS, or IP.
3. Masonry Cement: ASTM C91, Type S.
4. Lime: Hydrated lime, ASTM C207, Type S.
5. Aggregates:
 - a. Mortar: ASTM C144, acceptable in color, 10% passing No. 100 sieve.
 - b. Masonry Grout: ASTM C404.
6. Water Repellant Admixture:
 - a. Dry-Block by W.R. Grace & Co.
7. Water: Potable.
8. Coloring Pigments: Commercial iron oxide, manganese dioxide, or chromium oxide of color selected by Engineer.
9. Do not use antifreeze compounds.

B. Proportions:

1. Masonry Assembly Net Compressive Strength: f'_m = 2,500 pounds per square inch (minimum).
2. Concrete Masonry Unit Compressive Strength: f'_{cmu} = 3,250 pounds per square inch (minimum).
3. Mortar: ASTM C270, property specification Type S, 1,800 pounds per square inch (minimum).
4. Masonry Grout: ASTM C476, 2,500 pounds per square inch (minimum).
5. Use water repellant admixture in mortar for units exposed to earth or weather in accordance with manufacturer's written recommendations.

Concrete Masonry Units

- A. Hollow Normal Weight Concrete Block: ASTM C90.
- B. Appearance of new block shall match existing buildings.

Exterior Masonry Sealer

A. Manufacturers:

1. Chemstop WB Heavy Duty by Euclid Chemical Co.
2. Infiniseal DB by W.R. Grace & Co.

- B. Exterior breathable sealer compatible with water repellant admixture.

Execution

Surface Conditions. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

Concrete Masonry Units. Use normal weight block for interior partitions or backing for exterior walls. Use normal weight block with water repellant admixture where exposed to earth or weather.

Lay only dry masonry units. Use masonry saws to cut and fit masonry units. Set units plumb, true to line, and with level courses accurately spaced. Clean the top surface of foundation free from dirt and debris prior to start of installing first course. Accurately fit the units to plumbing, ducts, openings, and other interfaces, neatly patching all holes. Keep the walls continually clean, preventing grout and mortar stains. If grout does run over, clean immediately.

Unless otherwise shown on the Drawings, provide running bond with vertical joints located at center of masonry units in the alternate course below. Acoustic block shall be laid stack bond.

Do not use chipped or broken units. If such units are discovered in the finished wall, Engineer may require their removal and replacement with new units at no additional cost to the Owner.

Laying up:

1. Place units in mortar with full bed and head joints where cells are to be filled with mortar or masonry grout. Other masonry shall have face-shell bedding.
2. Align vertical cells of hollow units to maintain a clear and unobstructed system of flues.
3. Reinforce walls with continuous horizontal joint reinforcement spaced at 16 inches on center. Reinforce parapets with continuous horizontal joint reinforcement spaced at 8 inches on center. Lap reinforcement minimum of 8 inches, and stagger laps minimum of 32 inches.
4. Bond intersections of walls with horizontal joint reinforcement, conform to details shown.
5. Tie / reinforce cavity walls with horizontal joint reinforcement.
6. Where block laid against cast-in-place or precast concrete, provide vertical dovetail anchor slots at 2 feet on center with dovetail anchors at 16 inches on center.

Tooling:

1. Tool joints to a dense, smooth surface.
2. Unless otherwise shown on the Drawings, provide joints of "concave" pattern throughout.
3. Brush with soft brush to remove projecting mortar.
4. Cut mortar flush with surface on concealed surfaces.

Grouting. Perform grouting in strict accordance with the provisions of ACI 530.1.

1. Spaces to be grouted shall be free of mortar droppings, debris, and loose aggregate.
2. Provide cleanouts at the bottom of each cell containing vertical reinforcement when pour height exceeds 4 feet.
3. Solidly fill vertical cells containing reinforcement with masonry grout.
4. Fill cores under lintels with masonry grout.
5. Consolidate grout at time of pour by puddling with a mechanical vibrator, filling all cells of the masonry, and then reconsolidating later by puddling before the plasticity is lost.

Protection. Protect masonry from damage. Cover freshly laid masonry and walls not being worked on to prevent rapid drying and to exclude rain and snow. Brace walls until roof or floor system in place. Do not apply superimposed loads until completed masonry reaches design strength.

Cleaning. Clean as units are set, daily, and upon completion. Acid shall not be used. Remove surplus mortar and leave surface clean and finished.

Sealer. Apply 1 coat of exterior masonry sealer to exposed surfaces of concrete masonry. Protect windows, doors, louvers, light fixtures, etc. during application. Apply in accordance with manufacturer's recommendations.

THERMAL INSULATION

Summary. Section includes board insulation at perimeter concrete foundation walls.

References.

- A. ASTM: American Society for Testing and Materials

Performance Requirements. Materials of this section shall provide continuity of thermal barrier at building enclosure elements.

Submittals

- A. Product Data: Provide data on product characteristics, performance criteria, and limitations.
- B. Manufacturer's installation instructions.

Environmental Conditions. Do not install insulation adhesives when temperatures or weather conditions are detrimental to successful installation.

Products

Extruded Polystyrene Board (Perimeter Foundation)

- A. Rigid, closed-cell, extruded, polystyrene insulation with integral high-density skins.
- B. Minimum thermal resistance "R" per inch: 5.0.
- C. Minimum compressive strength:
 - 1. 25 pounds per square inch for perimeter wall and cavity wall insulation.
- D. Maximum water absorption by volume in accordance with ASTM C272: 0.1%.
- E. Manufacturers recommended adhesive for insulation application.
- F. Minimum thickness: 2 inches unless otherwise noted. Reduce thickness of cavity wall insulation at concrete beams and columns to 1 ½ inches.
- G. Acceptable Manufacturers:
 - 1. Dow.
 - 2. Owens Corning.
 - 3. Tenneco.
 - 4. Pactiv.

Execution

Installation / Extruded Polystyrene Board. Extruded polystyrene insulation to be installed where shown on the drawings, in accordance with manufacturer's instructions. Place boards in method to maximize contact bedding. Stagger side and end joints with edges butted tightly. Cut and fit boards tightly around penetrations and other openings as required. Perimeter insulation shall be set in adhesive applied to foundation wall in accordance with manufacturer's recommendations. Cavity wall insulation shall be set in adhesive applied to exterior face of interior wythe in accordance with manufacturer's recommendations. Fit courses of insulation between wall ties between wythes. Where thickness exceeds 2 inches, install first layer of insulation as specified herein. Stagger side and end joints of finish layer.

EPDM ELASTOMERIC MEMBRANE ROOFING (FULLY ADHERED)

Summary. Section includes UL Class A fire rated single-ply EPDM fully adhered membrane roofing and flashing system as shown and herein specified.

References

- A. ASTM: American Society for Testing and Materials
- B. UL: Underwriters Laboratories Inc.

Submittals

- A. Endorsement of Roofing Firm: System Manufacturer's endorsement of the installing firm.
- B. Shop Drawings:
 - 1. Roof insulation plan.
 - 2. Insulation fastener pattern.
 - 3. Base flashings.
 - 4. Reglets.
 - 5. Membrane terminations.
 - 6. Roof projection flashings.
 - 7. Sheet metal components:
 - 8. Counterflashing.
- C. Samples:
 - 1. Roof insulation: 8 inch x 10, inch 3 pieces.
 - 2. Insulation fastener: 3 of each.
 - 3. EPDM membrane: 8 inch x 10 inch, 3 pieces.
 - 4. Sheet metal components: 4 inch x 4 inch of each type, 3 pieces.
- D. Product Data:
 - 1. Vapor barrier.
 - 2. System Manufacturer's specifications and details for roofing system.
 - 3. Roof insulation specifications.
 - 4. Sheet metal components.

Quality Assurance

Qualifications: The installing contractor shall be approved or franchised by the roofing system manufacturer and shall have minimum 3 years experience installing the selected system.

Delivery, Storage, And Handling

- A. Per roofing system manufacturer's recommendations.
- B. Deliver materials requiring fire resistant classifications packaged with labels intact and legible.

1.02 Warranty

- A. Roof shall be warranted for a wind speed (maximum peak gusts) of 114 miles per hour.
- B. 20 year "No Dollar Limit" complete system Roofing System Manufacturer's Warranty:
 - 1. The Manufacturer warrants to the Owner that, subject to the provisions of this document, the Manufacturer will, at its own expense, make or cause to be made all

repairs necessary to maintain the roofing system in a watertight condition during the 20-year period following the date of Substantial Completion of the roofing system.

- a. System includes:
 - 1) Vapor barrier.
 - 2) Insulation.
 - 3) Membrane.
 - 4) Flashings.
 - 5) Fasteners and adhesives.
 - 6) Sheet metal components.

Products

Materials. Provide adhesives, sealants, premolded and field fabricated flashings, fasteners, and other related components manufactured or recommended by the selected system manufacturer.

Acceptable Roofing System Manufacturers

- A. Carlisle SynTec Systems.
- B. Elevate by Holcim.
- C. No Substitutes.

Acceptable Systems

- A. Fully adhered minimum 0.060 inch EPDM membrane.
 - 1. Carlisle: Design "A".
 - 2. Firestone: Rubbergard.

Roof Insulation

- A. The Contractor shall select a brand acceptable to the roofing system manufacturer.
- B. Materials:
 - 1. Rigid, closed-cell, polyisocyanurate insulation.
 - 2. Minimum thermal resistance "R" per inch: 6.0.
 - 3. Minimum compressive strength: 20 pounds per square inch.
- C. Tapered to provide minimum thickness and slopes as shown on the Drawings.

Insulation Fasteners. Adhesive or mechanical fasteners as recommended by the system manufacturer.

Metal Flashings

- A. Counterflashing: Mill Finish aluminum roll formed reglet and counterflashing in configurations shown on the drawings and as recommended by system manufacturer. Provide metal wedge inserts in wall counterflashings. Counterflashing is required over all termination bars.
 - 1. 2-Piece Counterflashing by Metal-Era, 0.040 inch
- B. Fascia: Kynar 500 Finish galvanized steel, 24 gauge. Face dimension of, and in configuration, shown on the drawings and as recommended by the system manufacturer. Factory Mutual 1- 90 approved.
 - 1. Anchor-Tite by Metal Era.
- C. Coping: 500 Finish galvanized steel, 24 gauge. Face dimension of, and in configuration, shown on the drawings and as recommended by the system manufacturer. Factory Mutual 1- 90 approved.
 - 1. Perma-Tite Coping by Metal Era.

Other Materials

- A. Vapor Barrier: Primer and membrane as recommended by the roofing system manufacturer.
- B. Ancillary Components: System manufacturer's standard accessory items.

Execution

Environmental Conditions: Install roofing only in dry weather. Comply with system manufacturer's climatic restrictions.

Inspection. Examine all surfaces for inadequate anchorage, foreign material, moisture, unevenness, or other conditions which could prevent the best quality and longevity of roofing, flashing, and accessory components. Notify the Engineer of all deficiencies. Do not proceed with the work until all deficiencies have been corrected to the satisfaction of the Engineer and the roofing system manufacturer.

Preparation. Ensure that all surfaces are clean and dry before starting and during performance of work. Verify that all work of other contractors and subcontractors which penetrates the roof deck or requires men and equipment to traverse the roof deck has been completed.

Installation

- A. Install vapor barrier over all roof surfaces and sidewalls as recommended by the roofing system manufacturer.
- B. Install the roof insulation with end joints staggered at mid-point in each layer. Offset all joints between layers a minimum of six inches.
 - 1. Install adhesive adhered insulation or mechanical fasteners per system manufacturer's recommendations.
 - 2. At penetrations, cut and fit insulation tightly to penetration.
 - 3. At roof drains, taper insulation to provide sump.
- C. Install the roofing and flashing system and all accessory items in accord with the system manufacturer's printed instructions.
- D. Install all field seams using the system manufacturer's seam tape, primers, and cleaners, and in accord with the system manufacturer's recommendations. Minimum seam lap shall be 3 inches.
- E. Centered over all field seams, apply a minimum 6 inch wide strip of pressure sensitive, self-adhering EPDM.

Field Quality Control. The roofing system manufacturer shall provide onsite observation and instruction as they deem necessary.

Adjust And Clean. Carefully inspect all completed work and correct all defects. Remove from the job site and legally dispose of all debris. Prevent storage of materials and equipment on the completed roof.

SHEET METAL FLASHING & TRIM

Summary. This Section includes sheet metal flashing and rim in the following categories:

1. Exposed trim, and fascia.
2. Metal flashing.
3. Reglets.

References

- A. ASTM: American Society for Testing and Materials
- B. AMACNA: Architectural Sheet Metal Manual

Performance Requirements. Install sheet metal flashing and trim to withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failing.

Submittals

- A. Product Data including manufacturer's material and finish data, installation instructions, and general recommendations for each specified flashing material and fabricated product.
- B. Samples of sheet metal flashing, trim, and accessory items, in the specified finish. Where finish involves normal color and texture variations, include Sample sets composed of 2 or more units showing the full range of variations expected.
 1. 8-inch square Samples of specified sheet materials to be exposed as finished surfaces.
 2. 6-inch long Samples of factory-fabricated products exposed as finished Work. Provide complete with specified factory finish.

Quality Assurance

- A. Installer Qualifications: Engage an experience Installer who has completed sheet metal flashing and trim work similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.

Products

Metals

- A. Copper: ASTM B370; temper H00, cold rolled except where temper 060 is required for forming; not less than 16 ounces per square foot, unless otherwise indicated.

Concealed Through-Wall Sheet Metal Flashing

- A. Material: Fabricate from the following metal:
 1. Copper: 10 ounces (0.34 millimeters thick) for full concealed flashing; 16 ounces (0.55 millimeters thick) elsewhere.
 2. Fabricate through-wall metal flashings embedded in masonry as follows:
 - a. With ribs formed in dovetail pattern at 3-inch intervals along length of flashing to provide a 3-way integral mortar bond and weep-hole drainage.
- B. Products: Subject to compliance with requirements, provide one of the following:
 1. Cheney Flashing (Dovetail); Cheney Flashing Company, Inc.
 2. Cheney Flashing (Sawtooth); Cheney Flashing Company, Inc.
 3. Keystone Three-Way Interlocking Thruwall Flashing; Keystone Flashing Co.

Reglets

- A. Units of type, material, and profile indicated, formed to provide secure interlocking of separate reglet and counterflashing pieces and compatible with flashing indicated.
- B. Masonry Type: Provide with offset top flange for embedment in masonry mortar joint.
- C. Counterflashing Wind-Restraint Clips: Provide clips to be installed before counterflashing to prevent wind uplift of the counterflashing lower edge.
 - 1. Material: Copper, 16 ounces per square foot, (0.55 millimeters thick).
- D. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Fry Reglet corporation.
 - 2. Hickman: W.P. Hickman Co.
 - 3. Keystone Flashing Company.

Miscellaneous Materials And Accessories

- E. Fasteners: Same metal as sheet metal flashing or other noncorrosive metal as recommended by sheet metal manufacturer. Match finish of exposed heads with material being fastened.

Execution

Examination. Examine substrates and conditions under which sheet metal flashing and trim are to be installed and verify that Work may properly commence. Do not proceed with installation until unsatisfactory conditions have been corrected.

Installation. Unless otherwise indicated, install sheet metal flashing and trim to comply with performance requirements, manufacturer's installation instructions, and AMACNA. Anchor units of Work securely in place by methods indicated, providing for thermal expansion of metal units; conceal fasteners where possible, and set units true to line and level as indicated. Install Work with laps, joints, and seams that will be permanently watertight and weatherproof.

Install exposed sheet metal Work that is without excessive oil canning, buckling, and tool marks and that is true to line and levels indicated, with exposed edges folded back to form hems. Install sheet metal flashing and trim to fit substrates and to result in waterproof and weather-resistant performance. Verify shapes and dimensions of surfaces to be covered before fabricating sheet metal.

Install reglets to receive counterflashing according to installation under Concrete Unit Masonry.

- A. Counterflashings: Coordinate installation of counterflashings with installation of assemblies to be protected by counterflashing. Install counterflashings in reglets or receivers. Secure in a waterproof manner by means of snap-in installation and sealant, lead wedges and sealant, interlocking folded seam, or blind rivets and sealant. Lap counterflashing joints a minimum of 2 inches and bed with sealant.

Cleaning And Protection. Clean exposed metal surfaces, removing substances that might cause corrosion of metal or deterioration of finishes. Provide final protection and maintain conditions that ensure sheet metal flashing and trim Work during construction is without damage or deterioration other than natural weathering at the time of Substantial Completion.

STAINLESS STEEL DOORS AND FRAMES

PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes:
 - 1. Stainless steel doors.
 - 2. Stainless steel door frames.

1.02 REFERENCES

- A. ANSI: American National Standards Institute
- B. NFPA: National Fire Protection Association
- C. ASTM: American Society for Testing and Materials
- D. DHI: The Door and Hardware Institute
- E. SDI: Steel Door Institute
- F. *UL: Underwriters Laboratories*

1.03 SUBMITTALS

- A. Product Data: For each type of door and frame indicated, include designation, type, level and model, material description, core description, construction details, label compliance, sound and fire-resistance ratings, and finishes.
- B. Shop Drawings:
 - 1. Elevations of each door and frame design.
 - 2. Details of doors including vertical and horizontal edge details.
 - 3. Frame details for each frame type including dimensioned profiles.
 - 4. Details and locations of reinforcement and preparations for hardware.
 - 5. Details of each different wall opening condition.
 - 6. Details of anchorages, accessories, joints, and connections.
 - 7. Coordination of glazing frames and stops with glass and glazing requirements.
- C. Schedule: Use same reference designations indicated on Drawings in preparing schedule for doors and frames.

1.04 QUALITY ASSURANCE

- A. Steel Door and Frame Standard: Comply with ANSI A250.8, unless more stringent requirements are indicated.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver doors and frames cardboard-wrapped or crated to provide protection during transit and job storage. Provide additional protection to prevent damage to finish of factory-finished doors and frames.
- B. Inspect doors and frames on delivery for damage, and notify shipper and supplier if damage is found. Minor damages may be repaired provided refinished items match new work and are acceptable to Architect. Remove and replace damaged items that cannot be repaired as directed.
- C. Store doors and frames at building site under cover. Place units on minimum 4-inch high wood blocking. Avoid using nonvented plastic or canvas shelters that could create a humidity chamber. If door packaging becomes wet, remove cartons immediately. Provide minimum 1/4-inch spaces between stacked doors to permit air circulation.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Amweld Building Products, Inc.
- B. Ceco Door Products.
- C. Curries Company.
- D. Kewanee Corporation.
- E. Steelcraft.

2.02 MATERIALS

- A. Hot-Rolled Steel Sheets: ASTM A568 or A569.
- B. Cold-Rolled Steel Sheets: ASTM A366.
- C. Metallic-Coated Steel Sheets: ASTM A 653, an A60 zinc-iron-alloy (galvannealed) coating,
- D. Stainless Steel Sheets: ASTM A240.

2.03 DOORS

- A. General: Provide doors of sizes, thicknesses, and designs indicated.
- B. Exterior Doors: Provide doors complying with requirements indicated below by referencing ANSI 250.8 for level and model and ANSI A250.4 for physical-endurance level:
 - 1. Level 3 and Physical Performance Level B (Extra Heavy Duty), Model 2 Seamless.
- C. Stainless Steel Doors: 16 ga. Type 304 stainless steel face sheets, No. 6 satin finish, polyurethane core. Internal reinforcement and parts shall be 304 alloy stainless steel, high corrosive resistance.

2.04 FRAMES

- A. General: Provide steel frames for doors and other openings that comply with ANSI A250.8 and with details indicated for type and profile. Conceal fastenings, unless otherwise indicated.
- B. Frames of 14 ga. thick steel sheet for:
 - 1. Level 3 steel doors.
- D. Door Silencers: Except on weather-stripped frames, fabricate stops to receive three silencers on strike jambs of single-door frames and two silencers on heads of double-door frames.
- E. Inserts, Bolts, and Fasteners: Manufacturer's standard units. Stainless steel as applicable.

2.05 FABRICATION

- A. General: Fabricate stainless steel door and frame units to comply with ANSI A250.8 and to be rigid, neat in appearance, and free from defects including warp and buckle. Where practical, fit and assemble units in manufacturer's plant. Clearly identify work that cannot be permanently factory assembled before shipment, to assure proper assembly at Project site.
- B. Exterior Construction: For exterior locations and elsewhere as indicated, fabricate doors and frames from Type 304 stainless steel sheet. Completely close top and bottom edges of doors flush as an integral part of door construction or by addition of 16 ga., stainless steel channels. Outside edges of doors shall be flush without depressions. No inverted channels will be allowed.
- C. Core Construction: Expanded polystyrene foam continuously bonded to steel skin.

- D. Clearances for Non-Fire-Rated Doors: Not more than 1/8 inch at jambs and heads, except not more than 1/4 inch between pairs of doors. Not more than 3/4 inch at bottom.
- E. Single-Acting, Door-Edge Profile: Square edge.
- F. Tolerances: Comply with SDI 117.
- G. Fabricate concealed stiffeners, reinforcement, edge channels, louvers, and moldings from either cold- or hot-rolled steel sheet.
- H. Exposed Fasteners: Unless otherwise indicated, provide countersunk flat or oval heads for exposed screws and bolts.
- I. Hardware Preparation:
 - 1. Prepare doors and frames to receive mortised and concealed hardware according to door hardware schedule and templates provided by hardware supplier. Comply with applicable requirements in ANSI A250.6 and ANSI A115 Series specifications for door and frame preparation for hardware.
- J. Frame Construction:
 - 1. Fabricate frames to shape shown.
 - 2. Fabricate frames with mitered or coped and continuously welded corners and seamless face joints with all surface welds, joints and seams filled and ground smooth.
 - 3. Provide temporary spreader bars.
- K. Reinforce doors and frames to receive surface-applied hardware. Drilling and tapping for surface-applied hardware may be done at Project site.
- L. Locate hardware as indicated on Shop Drawings or, if not indicated, according to ANSI A250.8.
- P. Glazing Stops: Manufacturer's standard, formed from 0.032-inch thick steel sheet.
 - 1. Provide nonremovable stops on outside of exterior doors and on secure side of interior doors for glass, louvers, and other panels in doors.
 - 2. Provide screw-applied, removable, glazing stops on inside of glass, louvers, and other panels in doors.

2.06 FINISHES

- A. Standard Stainless Steel Finish: #2B Mill Finish.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. General: Install steel doors, frames, and accessories according to Shop Drawings, manufacturer's data, and as specified.
- B. Placing Frames:
 - 1. Comply with provisions in SDI 105, unless otherwise indicated.
 - 2. Set frames accurately in position, plumbed, aligned, and braced securely until permanent anchors are set.
 - 3. After wall construction is completed, remove temporary braces and spreaders, leaving surfaces smooth and undamaged.
 - 4. Except for frames located in existing walls or partitions, place frames before construction of enclosing walls and ceilings.
 - 5. In masonry construction, provide at least three wall anchors per jamb; install adjacent to hinge location on hinge jamb and at corresponding heights on strike jamb. Acceptable anchors include masonry wire anchors and masonry T-shaped anchors.
 - 6. Install fire-rated frames according to NFPA 80.

7. For openings 90 inches or more in height, install an additional anchor at hinge and strike jambs.
 - C. Door Installation:
 1. Comply with ANSI A250.8 unless otherwise indicated.
 2. Fit hollow-metal doors accurately in frames, within clearances specified in ANSI A250.8.
 3. Shim as necessary to comply with SDI 122 and ANSI/DHI A115.1G.
- 3.02 ADJUSTING AND CLEANING
- A. Protection Removal: Immediately before final inspection, remove protective wrappings from doors and frames.

DOOR HARDWARE

PART 1 – GENERAL

- 1.01 SUMMARY
 - A. Section includes:
 1. Hardware for stainless steel doors.
- 1.02 REFERENCES
 - A. NEMA: National Electrical Manufacture's Association
 - B. BHMA: Builders Hardware Manufacture's Association
 - C. ANSI: American National Standards Institute
 - D. UL: Underwriter Laboratories
- 1.03 QUALITY ASSURANCE
 - A. Manufacturers: Companies specializing in manufacturing door hardware with a minimum of three years of experience.
 - B. Installer Qualifications: Supplier of products and an employer of workers trained and approved by product manufacturers and of an Architectural Hardware Consultant who is available during the work to consult the Contractor, Project Engineer/Manager, Architect, and Owner about door hardware and keying.
 - C. Keying Conference: conduct conference at project site.
 1. Incorporate conference decisions into keying schedule after reviewing door hardware keying system including, but not limited to, the following:
 - a. Flow of traffic and degree of security required.
 - b. Preliminary key system schematic diagram.
 - c. Requirements for key control system.
 - d. Requirements for access control.
 - e. Address for delivery of keys.
- 1.04 SUBMITTALS
 - A. Shop Drawings. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - B. Product Data. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - C. Door Hardware Schedule: Prepared by or under the supervision of Installer's Architectural Hardware Consultant. Coordinate door hardware schedule with doors, frames, and related work to ensure proper size, thickness, hand, function, and finish of door hardware.

1. Submittal Sequence: Submit door hardware schedule concurrent with submissions of Product Data, Samples, and Shop Drawings. Coordinate submission of door hardware schedule with scheduling requirements of other work to facilitate the fabrication of other work that is critical in Project construction schedule.
2. Format: Use same scheduling sequence and format and use same door numbers as in door hardware schedule in the Contract Documents.
3. Content: Include the following information:
 - a. Identification number, location, hand, fire rating, size, and material of each door and frame.
 - b. Locations of each door hardware set, STC rating, cross-referenced to drawings on floor plans and to door and frame schedule.
 - c. Complete designations, including name and manufacturer, type, style, function, size, quantity, function, and finish of each door hardware product.
 - d. Description of electrified door hardware sequences of operation and interfaces with other building control systems.
 - e. Fastenings and other installation information.
 - f. Explanation of abbreviations, symbols, and designations contained in door hardware schedule.
 - g. Mounting locations for door hardware.
 - h. List of related door devices specified in other Sections for each door and frame.
4. Keying Schedule: Prepared by or under the supervision of Installer's Architectural Hardware Consultant, detailing Owner's final keying instructions for locks. Include schematic keying diagram and index each key set to unique door designations that are coordinated with the Contract Documents.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Package hardware items individually; label and identify package with door opening code to match hardware schedule.
- B. Protect hardware from theft by cataloging and storing in secure area.
- C. Include installation instructions, templates, and necessary fasteners with each item or package.

PART 2 – PRODUCTS

1.01 ACCEPTABLE MANUFACTURERS:

- A. Exit Devices: Rim type x stainless steel x US 32D. Provide compatible F08 heavy duty exit device trim for exterior doors and compatible passage type exit device trim for interior doors. ANSI A115.2, A115.18 cylinder lock, BHMA A156.3. Keyed access with trim lever handle mounted on exterior side of door leaf. Include dogging function and cylinder locks. Basis of design - Precision Apex 2000 Series.
 1. Single doors:
 - a. ED5200 Corbin Russwin
 - b. Apex 2000 Precision
- B. Hinges x 4-1/2 x 4-1/2 x US 32D.
 1. FBB 191 Stanley
 2. BB 4101 Lawrence
- C. Closers x delayed action x AL - size as recommended by manufacturer. Install closers on room side, using parallel arms where necessary. Basis of design: Best HD8016 series.

1. HD8016 Series Best
2. 4010 / 4110 Series LCN
3. 8900 Series dormakaba
- D. Kick Plates – 10 inch x 2 inch LDW x US 32D x 16GA.
 1. Brookline
 2. Ives
 3. Hiawatha
 4. Rockwood
- E. Thresholds - set in sealant 5 inch x 1/2 inch Clear Anodized Aluminum Thermally Broken Saddle x frame width.
 1. S282A x AL Reese
 2. 252 x 3AFG x AL Pemko
 3. 8425 x AL National Guard
- F. Door Bottom - Mill Aluminum with thermoplastic rubber.
 1. DB594AU Reese
 2. 222APK Pemko
 3. 15NA National Guard
- G. Weatherstrip – Clear Anodized Aluminum.
 1. DS 69C Reese
 2. 110 NA National Guard
 3. 332 CR Pemko
- H. IDOT Standard Outside Deadbolt.
 1. Heavy duty, high security padlock locking bolt with a $\frac{3}{4}$ " throw adjustable from $\frac{3}{4}$ " to 2-3/8" shall be provided mounted on the exterior of doors. Doors shall be reinforced as necessary for installation of the outside deadbolt. Heavy duty padlock for the doors will be provided by IDOT.

1.02 KEYING

- A. Supply 5 keys for each lock.
- B. Keys shall match Department's keying system.
- C. Serial numbers shall be stamped or engraved on all keys.
- D. When possible, key to existing system.

1.03 FINISHES

- A. Manufacturer responsible for surface preparation and priming. Coordinate finish color with Engineer.
- A. Finishes are US 32 satin stainless steel unless otherwise noted. Closer finishes may be paint.

PART 3 – EXECUTION

3.01 INSPECTION

- A. Verify that doors and frames are ready to receive work and dimensions are as indicated on shop drawings.
- B. Beginning of installation means acceptance of existing conditions.

3.02 INSTALLATION

- A. Install hardware in accordance with manufacturer's instructions.
- B. Use the templates provided by hardware item manufacturer.

3.03 **HARDWARE SCHEDULE**

- A. Set No. 1 (Door D01)
 - 1. 1-1/2 PR Butts x NRP
 - 2. 1 Exit Device with keyed access and lever trim exterior side
 - 3. 1 Closer x 110 degrees x HO
 - 4. 1 Kickplate
 - 5. 1 Weatherstripping
 - 6. 1 Door Bottom
 - 7. 1 Threshold
 - 8. 1 IDOT Std. Deadbolt

LOUVERS

PART 1 – GENERAL

1.01 **SUMMARY**

- A. Extent of louver work is indicated by drawings and schedules, and by requirements of this Section.
- B. Types of outlets and inlets required for project include the following:
 - 1. Louvers.

1.02 **REFERENCES**

- A. Standard References:
 - 1. AMCA: Air Movement and Control Association
 - 2. ANSI: American National Standards Institute.
 - 3. NFPA: National Fire Protection Association.

1.03 **SUBMITTALS**

- A. General:
 - 1. Submit Product Data in sufficient detail to confirm compliance with requirements of this Section. Submit Product Data and Shop Drawings in one complete submittal package. Partial submittals are unacceptable.
- B. Product Data:
 - 1. Schedule of outlets and inlets indicating drawing designation, model number, size, and accessories furnished.
 - 2. Data sheet for each type of outlet and inlet, and accessory furnished; indicating construction, finish, and mounting details.
 - 3. Performance data for each type of outlet and inlet furnished, including pressure drop, throw and drop, and noise criteria ratings. Indicate selections on data.
- C. Submit manufacturer's recycled content percentage or certification for supplied products.
- D. Maintenance Data:
 - 1. Operating instructions and maintenance data for materials and products for inclusion in O&M Manual.

1.04 **QUALITY ASSURANCE**

- A. Manufacturer Qualifications: Firms experienced in manufacturing equipment of types and capacities indicated that have record of successful in-service performance.
- B. Regulatory Requirements:
 - 1. AMCA Standards - Comply with Air Movement and Control Association, Inc. (AMCA) Standard 500 "Test Method For Louvers, Dampers and Shutters".
 - 2. ANSI/NFPA Standards - Comply with National Fire Protection Association (NFPA) Standard 90A "Installation of Air Conditioning and Ventilating Systems".

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver outlets and inlets wrapped in factory-fabricated fiberboard type containers. Identify on outside of container type of outlet or inlet and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in devices.
- B. Store outlets and inlets in original cartons and protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

PART 2 – PRODUCTS

2.01 LOUVERS

- A. Manufacturers:
 - 1. Greenheck.
 - 2. Pottorff.
 - 3. Ruskin.
 - 4. Carnes.
 - 5. Or equal.
- B. Construction: Provide louvers constructed of aluminum extrusions, Alloy 6063-T5. Weld units or use stainless steel fasteners.
- C. Performance: Provide weatherproof louvers of sizes as shown in schedules or on drawings. Louvers shall not exceed scheduled maximum values for free area face velocity and pressure drop at scheduled airflow rates. Intake air louvers shall not have a rated minimum water entrainment velocity lower than the scheduled maximum free area velocity.
- D. Substrate Compatibility: Provide louvers with frame and sill styles that are compatible with adjacent substrate and specifically manufactured to fit into construction openings with accurate fit and adequate support for weatherproof installation. Refer to Drawings and Specifications for types of substrates which will contain each type of louver.
- E. Finish: Provide louvers with AAMA 2605 compliant 70% polyvinylidene fluoride (PVDF) finish. Finish color to be selected by Architect.
- F. Accessories: Provide louvers with the following accessories as scheduled:
 - 1. Bird Screen: Provide manufacturer's standard aluminum bird screen mounted on inside face of louver.
 - 2. Extended sill.
 - 3. Flanged frame.

PART 3 – EXECUTION

3.01 EXAMINATION

- A. Examine areas and conditions under which louvers are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install louvers in accordance with manufacturer's written instructions.
- B. Check location of louvers and make necessary adjustments in position to conform to architectural features, symmetry, and lighting arrangement.

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 – GENERAL

1.01 DESCRIPTION OF WORK

- A. Extent of testing, adjusting, and balancing work is indicated by requirements of this section, and also by drawings and schedules, and is defined to include, but is not necessarily limited to:
 - 1. Air distribution systems and associated equipment.
- B. The work consists of setting speed and volume (flow) adjusting facilities provided for systems, recording data, conducting tests, preparing and submitting reports, and recommending modifications to work as required by contract documents.
- C. Component types of testing, adjusting, and balancing specified in this section includes the following as applied to mechanical equipment:
 - 1. Fans.
 - 2. Ductwork systems.

1.02 QUALITY ASSURANCE

- A. A firm certified by National Environmental Balancing Bureau (NEBB), Associated Air Balance Council (AABC), or Testing, Adjusting and Balancing Bureau (TABB) in those testing and balancing disciplines similar to those required for this project.
- B. Comply with American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) recommendations pertaining to measurements, instruments and testing, adjusting and balancing, except as otherwise indicated and NEBB "Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems".

1.03 DEFINITIONS

- A. Balancing Contractor: NEBB or TABB certified Contractor completing work of this Section.

1.04 SUBMITTALS

- A. Submit certified test reports signed by Test and Balance (TAB) Supervisor who performed TAB work.
- B. Reports shall be on NEBB forms unless other forms have been approved by the Engineer prior to the start of testing.
- C. Include identification and types of instruments used and their most recent calibration date with submission of final test report.
- D. Include copies of certified test reports in maintenance manuals.

1.05 JOB CONDITIONS

- A. Do not proceed with testing, adjusting, and balancing work until work has been completed and is operable. Ensure that there is no work still to be completed.
- B. Do not proceed until work scheduled for testing, adjusting, and balancing is clean and free from debris, dirt and discarded building materials.

PART 2 – PRODUCTS

2.01 PATCHING MATERIALS

- A. Except as otherwise indicated, use same products as used by original Installer for patching holes in insulation, ductwork and housings which have been cut or drilled for test purposes, including access for test instruments, attaching jigs, and similar purposes.
- B. At Tester's option, plastic plugs with retainers may be used to patch drilled holes in ductwork and housings.

PART 3 – EXECUTION

3.01 EXAMINATION

- A. Examine installed work and conditions under which testing is to be done to ensure that work has been completed, cleaned and is operable. Do not proceed with TAB work until unsatisfactory conditions have been corrected in manner acceptable to Tester.
- B. Inspect system to ensure filters and strainers are clean, that all valves and dampers are in correct open position, and that all access doors are closed. Notify Contractor of any observed deficiencies and wait for correction prior to initiating balancing work.
- C. Confirm with HVAC Controls Contractor that all controls for systems to be balanced are fully functional and in operation prior to balancing.

3.02 TEST AND ADJUSTMENT

- A. Test, adjust and balance environmental systems and components, as indicated, in accordance with procedures outlined in applicable standards.
- B. Prepare report of test results, including instrumentation calibration reports, in format recommended by applicable standards.
- C. Air side system balancing shall include but not be limited to the following procedures:
 - 1. Test and adjust fan RPM to design requirements.
 - 2. For fans operating with pressure controlled VFDs, fan speed shall first be set to lowest output that allows design flow to most remote terminal served. Measured minimum required supply air pressure shall be identified to the HVAC Controls Contractor for establishing setpoint in the HVAC control system.
 - 3. Test and record motor full load amperage.
 - 4. Check all fans for correct rotation.
 - 5. All air testing of equipment with internal filters shall be completed with a clean set of filters in place.
 - 6. Test and record system static pressures, suction, discharge, and external at all air handling equipment. Test and record static pressure upstream and downstream of filters, dampers, and coils internal to all air handling equipment. Measurements for air handling units serving VAV system shall be taken after all VAVs and diffusers have been balanced and while VAVs are manually positioned such that air handling unit design airflow is being supplied. Measurements shall be taken and recorded at both minimum outside airflow rate and 100% outside airflow rate.
 - 7. System airflow measurements taken on systems with installed airflow measurement shall be compared to value measured by HVAC Control System and both values shall be logged. Differences of greater than 5% required flow rate shall be identified and corrected to obtain common readings.
 - 8. Test and adjust system for design outside air and recirculated air quantities.
 - 9. Adjust and record all main supply and return air ducts and zones to proper design CFM.
 - 10. Test and adjust each diffuser, grille and register to within (+)10%, (-)0% of design requirements. Record data and location. Use manufacturer's rating and calculations.
 - 11. Adjust all grilles to minimize drafts in all areas.
 - 12. Test and record all air temperatures: supply, return, mixed, and outside air.
- D. The Balancing Contractor shall include the cost of new sheaves and belts if it becomes necessary to change the drives during balancing of system.
- E. Patch holes in ductwork and housings, which have been cut or drilled for test purposes, in manner recommended by original Installer.

- F. Mark equipment settings, including damper control positions, fan speed control levers, and similar controls and devices, to show final settings at completion of TAB work. Provide markings with paint or other suitable permanent identification materials.
- G. Balancing Contractor shall coordinate damper position settings with HVAC Control Contractor to verify airflows and positions. Include time for this verification. See HVAC controls specification for time included by HVAC Controls Contractor to work with Balancing Contractor.
- H. Balancing Contractor to work with HVAC Controls Contractor and HVAC Contractor to verify correct operation of entire HVAC system, before submitting report.

MECHANICAL INSULATION

PART 1 - GENERAL

- 1.01 DESCRIPTION OF WORK
 - A. Extent of mechanical insulation specified in this section includes Piping and Ductwork Systems (where indicated).
- 1.02 QUALITY ASSURANCE
 - A. Installation shall meet the requirements Illinois Plumbing, Mechanical, and Energy Codes.
 - B. Manufacturer - Subject to compliance with requirements, provide products of one of the following:
 - 1. Armstrong World Industries, Inc.
 - 2. Certainteed Corp.
 - 3. Knauf Fiberglass
 - 4. Manville Corp.
 - 5. Owens-Corning Fiberglass Corp.
 - 6. Pittsburg Corning Corp.
 - 7. Rubatex Corp.
 - C. Installer - A firm with at least 3 years successful installation experience on projects with mechanical insulation similar to that required for this project.
 - D. Flame/Smoke Ratings - Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread rating of 25 or less, and smoke- developed rating of 50 or less, as tested by ANSI/ASTM E 84 (NFPA 255) method.
- 1.03 SUBMITTALS
 - A. Product Data - Submit manufacturer's specifications and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, thickness, and furnished accessories for each mechanical system requiring insulation.
 - B. Maintenance Data - Submit maintenance data and replacement material lists for each type of mechanical insulation.
- 1.04 DELIVERY, STORAGE AND HANDLING
 - A. Deliver insulation, coverings, cements, adhesives, and coatings to site in containers with manufacturer's stamp or level, affixed showing fire hazard ratings of products.
 - B. Protect insulation against dirt, water, and chemical and mechanical damage. Do not install damaged insulation; remove from project site.

PART 2 – PRODUCTS

2.01 DUCTWORK INSULATION MATERIALS

A. External Duct Insulation:

1. Rigid Fiberglass Ductwork Insulation: ASTM C612, rigid fibrous glass board. Knauf Insulation Board, or equal.
 - a. Load Bearing: ASTM C612, Type IB; HH-I-558C, Form A, Class 2, average density 6.0 pcf, maximum $k = 0.22 \text{ Btu in./hr sq ft } ^\circ\text{F}$ at 75°F . Suitable for operating temperatures to 400°F .
 - b. Jacketing: Aluminum Foil Faced Vapor Barrier Material: All service type aluminum foil and fiberglass yarn reinforced kraft paper. FSK type conforming to ASTM C1136 Type II.
 - c. Maximum water vapor permeability, ASTM E96, 0.02 perms.

PART 3 - EXECUTION

3.01 SYSTEM INSULATION

A. HVAC Ductwork Insulation:

1. Insulate all outside air ductwork from intake louver to filter housing with 1" thickness of load bearing rigid fiberglass ductwork insulation.

3.02 INSTALLATION OF INSULATION

- A. Install insulation products in accordance with manufacturer's written instructions.
- B. Install insulation on pipe systems subsequent to testing and acceptance of tests.
- C. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with single cut piece to complete run. Do not use cut pieces or scraps abutting each other.
- D. Clean and dry pipe surfaces prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.
- E. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage.
- F. Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job fabricated units (at Installer's option) except where specific form or type is indicated.
- G. Extend piping insulation without interruption through walls, floors, and similar piping penetrations, except where otherwise indicated.
- H. Install protective metal shields and insulated inserts wherever needed to prevent compression of insulation.

3.03 PROTECTION AND REPLACEMENT

- A. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.
- B. Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

TEMPERATURE CONTROL SYSTEMS FOR HVAC

PART 1 – GENERAL

1.01 SUMMARY

- A. Furnish all labor, materials, equipment, and service necessary for a complete and operating control system utilizing electronic controls as described herein.
- B. Control wiring and power wiring between field installed controls, indicating devices and unit control panels for temperature control systems, is work of this Section to be installed in accordance with Division 26. Line or low voltage power wiring required for control devices including but not limited to motor operated dampers, sensors, control valves, and thermostats that are not powered by equipment served shall receive power from the nearest temperature control panel (TCP) as work of this Section. Coordinate total ampere load in panel with Electrical Contractor to determine total number of circuits required at the TCP.

1.02 DEFINITIONS AND ABBREVIATIONS

- A. Definitions:
 - 1. Wiring: Raceway, fittings, wire, boxes and related items.

1.03 SUBMITTALS

- A. Product Data - Submit manufacturer's specifications for each control device furnished, including installation instructions and start-up instructions. At a minimum include:
 - 1. Complete written Sequence of Operation with graphical depiction of the application control program.
 - 2. Schematic diagram for each control system.
 - 3. Electrical wiring diagram showing all equipment and control devices and terminal identification. Clearly differentiate between factory-installed and field-installed wiring.
 - 4. Complete list of equipment and materials to be provided including Manufacturer's catalog data on each component.
- B. Maintenance Data - Submit maintenance data and spare parts lists for each type of control device. Include this data in maintenance manual. At a minimum include:
 - 1. Maintenance instructions and schedule of recommended maintenance for pieces of equipment that require routine maintenance.
 - 2. Sequence of Operation.
 - 3. Logic diagrams.
 - 4. Wiring Diagram.
 - 5. Recommended spare parts list.
- C. Operation and Maintenance Manuals:

1.04 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of electric, and digital control equipment of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.
- B. The Manufacturer of the DDC controllers shall provide documentation supporting compliance with ISO-9001 (Model for Quality Assurance in Design/Development, Production, Installation and Servicing). Product literature provided by the FMCS digital controller manufacturer shall contain the ISO-9001 Certification Mark from the applicable registrar.
- C. Installer: Provide documentation showing a minimum of 5-years of experience installing submitted Manufacturer's equipment for projects of similar size and scope.

- D. Electrical Standards: Provide electrical products which have been tested, listed and labeled by Underwriters' Laboratories (UL) and comply with NEMA standards.
 - E. NEMA Compliance: Comply with NEMA standards pertaining to components and devices for electric-electronic temperature control systems.
 - F. NFPA Compliance: Comply with NFPA No. 90A where applicable to controls and control sequences.
 - G. Single-Source Responsibility: Obtain DDC components from single manufacturer with responsibility for entire system.
 - H. Regulatory Requirements:
 - 1. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with the current editions in effect 30 days prior to the receipt of bids of the following codes:
 - a. National Electric Code (NEC)
 - b. International Building Code (IBC)
 - c. International Mechanical Code (IMC)
 - d. ANSI/ASHRAE Standard 135, BACnet - A Data Communication Protocol for Building Automation and Control Systems
- 1.05 DELIVERY, STORAGE, AND HANDLING
- A. Provide factory-shipping cartons for each piece of equipment, and control device. Maintain cartons through shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment. Store equipment and materials inside and protected from weather.
- 1.06 JOB CONDITIONS
- A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to insure that the Work will be carried out in an orderly fashion. It shall be this Contractor's responsibility to check the Contract Documents for possible conflicts between his Work and that of other crafts in equipment location, pipe, duct and conduit runs, electrical outlets and fixtures, air diffusers, and structural and architectural features.

PART 2 – PRODUCTS

- 2.01 GENERAL
- A. Provide temperature control products in sizes and capacities indicated, consisting of dampers, thermostats, sensors, controllers, and other components as required for complete installation. Except as otherwise indicated, provide manufacturer's standard temperature control system components as indicated by published product information, designed and constructed as recommended by manufacturer.
- 2.02 INSTALLER
- A. Installer shall have an established working relationship with Direct Digital Controls components Manufacturer.
 - B. Installer shall have successfully completed Control System Manufacturer's control system training. Upon request, Installer shall present record of completed training including course outlines.
- 2.03 DAMPERS
- A. General:
 - 1. No single damper shall be larger in size than 48-in in either dimension. Where a larger damper is required, multiple damper assemblies shall be provided.
 - 2. Where multiple damper assemblies are provided, a common actuator may be used to drive a maximum of four dampers. Provide stainless steel connecting

linkage as required. Where an assembly is constructed of more than four dampers, multiple actuators shall be provided.

B. Insulated Control Dampers:

1. Manufacturer:
 - a. Greenheck model ICD-45.
 - b. Or equal.
2. 0.125-in aluminum channel frame insulated with polystyrene on four sides and thermally broken with dual polyurethane resin gaps.
3. Aluminum airfoil blades internally insulated with polyurethane foam and thermally broken.
4. Plated steel axle with dual bearings. Bearings shall have acetal inner sleeve and flanged outer bearing with no metal-to-metal or metal-to-plastic contact.
5. External (out of the airstream) blade to blade linkage.
6. Suitable for pressures to 8-in. w.c. and velocities to 4,000-fpm with maximum AMCA leakage rate of 8 cfm/sq. ft at 4-in w.c.

C. Damper Actuators:

1. Actuators shall be adequately sized for the damper size and air pressures anticipated in the system with a safety factor of two.
2. Actuators shall have ISO9001 quality certification and be UL listed under standard 60730-1 or UL listed under standard 873.
3. Actuators used on dampers shall be designed to directly couple and mount to a stem, shaft or ISO style-mounting pad. Actuator mounting clamps shall be a V-bolt with a toothed V- clamp creating a cold weld, positive grip effect. Single point, bolt, or single screw actuator type fastening techniques or direct-coupled actuators requiring field assembly of the universal clamp is not acceptable.
4. Actuators shall be fully modulating/proportional, pulse width, floating/tristate, or two position as indicated in the sequence of operation and be factory or field selectable. Actuators shall have visual position indicators and shall operate in sequence with other devices if required.
5. Provide actuators with end switches or position feedback as indicated in the sequences of operation.
6. Actuators shall have an operating range of -22° to 122°F.
7. Proportional actuators shall accept a 0-10 VDC or 0-20 mA input signal and provide a 2-10 VDC or 4-20 mA (with a 500 W load resistor) operating range.
8. Actuators shall be capable of operating on 24 or 120 VAC, or 24VDC and Class 2 wiring as dictated by the application. Power consumption shall not exceed 10 VA for AC, including 120VAC actuators, and 8 watts per actuator for DC applications. Unless specifically scheduled, power supply requirements are Contractors option.
9. Actuators shall have electronic overload protection or digital rotation sensing circuitry to prevent actuator damage throughout the entire rotation. End switches to deactivate the actuator at the end rotation or magnetic clutches are not acceptable.
10. For power-failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Spring return actuators shall be capable of CW or CCW mounting orientation. Spring return models > 60 in-lbs. and non-spring return models > 90 in- lbs. shall be capable of mounting on shafts up to 1.05-in diameter. Spring return actuators with more than 60 in-lb. of torque shall have a metal, manual override crank. Actuators using "on-board" chemical storage systems, capacitors, or other "on-board" non-mechanical forms of fail-safe operation are unacceptable. Upon loss of control signal, a proportional

actuator shall fail open or closed as described below. Upon loss of power, a nonspring return actuator shall maintain the last position.

11. Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required. Dampers requiring greater torque or higher close off may be assembled with multiple low torque actuators. Dual mounted actuators using additional anti-rotation strap mechanical linkages, or special factory wiring to function are not acceptable. Actuators in a tandem pair must be "off the shelf," standard actuators ready for field wiring.
12. Damper actuators shall not produce more than 62 dB (A) when furnished with a mechanical fail-safe spring. Non-spring return actuators shall conform to a maximum noise rating of 45 dB(A) with power on or in the running or driving mode.
13. Proportional actuators shall be fully programmable. Control input, position feedback and running time shall be factory or field programmable. Diagnostic feedback shall provide indications of hunting or oscillation, mechanical overload, mechanical travel and mechanical load limit. The actuators shall also provide actuator service data, at minimum, number of hours powered and number of hours in motion.
14. Proportional actuators shall be capable of digital communication, as built.
15. All damper operators shall be oil submerged, geartrain type, inherently positive positioning.
16. The actuators shall be mounted externally of ducts or air handling equipment wherever possible for ease of service and isolated from internal temperatures.
17. Actuator enclosure:
 - a. Unless otherwise indicated, NEMA 2.
18. Fail Position:
 - a. Intakes/Exhausts connecting to generator rooms: Open.
 - b. All other Intakes/Exhausts: Closed.

2.04 INSTRUMENTATION

A. Temperature Sensors

1. Temperature Sensors shall be of the type and have accuracy ratings as indicated and/or required for the application and shall permit accuracy rating of within 1% of the temperature range of their intended use. Sensors must be capable of being calibrated.
2. Provide sensors such that the FMS/TCS shall be able to convert the resistive input signal available from the element into a digital signal for use by the FMS/TCS.
3. All duct sensors shall be electronic resistance type.
4. Sensors used for mixed air application shall be the averaging type of sufficient length to extend diagonally across the entire duct and have an accuracy of 1%.
5. Duct sensors shall protrude into the air stream far enough to sense any temperature differences due to stratification, etc.
6. Outside air sensors shall have a minimum range of -20°F to 110°F and an accuracy of within 1°F in this temperature range. Sensors shall be provided with a water-tight fitting and adequate protection from the effects of solar radiation.
7. Space temperature sensors located in the Administrative Spaces shall have digital space temperature and setpoint display with external setpoint adjustment and manual Occupied/Unoccupied override. Setpoint adjustment shall be software limited by the operator interface.
8. Space temperature sensors located in process spaces shall be provided with a NEMA 4X enclosure with corrosion resistant elements. Sensors shall have no

setpoint adjustment or display. Space temperature setpoint shall be made via the operator interface.

9. Space temperature sensors located in areas identified and Class 1, Division 1 or 2 shall be provided with an explosion proof enclosure with corrosion resistant elements. Sensors shall have no setpoint adjustment or display. Space temperature setpoint shall be made via the operator interface.
 10. Water temperature sensors shall be of the bulb type mounted within stainless steel wells filled with a heat conductive compound and in direct contact with the water within the pipe.
 11. All field mounted sensors shall be labeled in accordance with the name or identification number used in the control program.
- B. Low Temperature Protection Thermostats
1. Provide low-temperature protection thermostats of manual-reset type with sensing elements 8'-0" or 20'-0" in length.
 2. Provide thermostat designed to operate in response to coldest 1'-0" length of sensing element, regardless of temperature at other parts of element.
 3. Support element properly to cover entire unit width.
- C. Line-voltage/low voltage on-off thermostats
1. Bi-metal actuated open contact, or bellows actuated enclosed snap-switch type.
 2. UL-listed at electrical rating comparable with application.
 3. Heat anticipation.
- D. Line-voltage reverse-acting thermostats
1. Bi-metal actuated open contact, or bellows actuated enclosed snap-switch type.
 2. UL-listed at electrical rating comparable with application.
 3. Cooling anticipation.
- 2.05 TEMPERATURE CONTROL PANELS (TCP)
- A. Provide control panels with suitable brackets for either wall or floor mounting where indicated and elsewhere as required. Locate panel as indicated and required.
 - B. Provide standard NEMA 1 or 12 cabinets of size required to contain relays; switches; and similar devices; except limit controllers and other devices excluded in sequence of operations.
 - C. Mount required alarm lights, indicating devices and manual controls on face of panel.

PART 3 – EXECUTION

3.01 GENERAL

- A. All necessary equipment, labor, and materials not specifically indicated or specified, but necessary to complete work, are to be provided as part of the Contract.
- B. Install all control equipment, accessories, wiring, and piping in a neat and workman like manner. All control devices must be installed in accessible locations.
- C. Provide all electrical relays and wiring, line and low voltage, for control systems, devices, and components.
- D. Install system and materials in accordance with manufacturer's instructions and roughing-in drawings, and details on drawings. Install electrical work and use electrical products complying with requirements of applicable Division 26 sections of these specifications. Mount controller at convenient locations and heights.
- E. Install "Hand-Off-Auto" selector switches on systems where automatic interlock controls are specified. When switch is in the "Hand" position, allow manual operation of the selected device without the operation of the interlocked motors but allowing unit safety devices to stay in the circuit. When air handling units are in the "Hand" mode, outside air damper shall be open. When fans interlocked with motor operated intake dampers are in the "Hand" mode, associated damper shall open.

3.02 EXAMINATION

- A. The Contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the engineer for resolution before rough-in work is started.
- B. The Contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate or if any discrepancies occur between the plans and the Contractor's work and the plans and the work of others, Contractor shall report discrepancies to the Engineer and shall obtain written instructions for any changes necessary to accommodate Contractor's work with work of others. Any changes in work covered by this Section made necessary by the failure or neglect of the Contractor to report such discrepancies shall be made by and at the expense of, this Contractor.

3.03 PROTECTION

- A. Contractor shall protect all work and material from damage by his/her work or employees and shall be liable for all damage thus caused.
- B. Contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. Contractor shall protect any material that is not immediately installed. Contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.04 COORDINATION

- A. Site:
 - 1. Where the mechanical work will be installed in close proximity to, or will interfere with, work of other trades, Contractor shall assist in working out space conditions to make a satisfactory adjustment. If Contractor installs his/her work before coordinating with other trades, so as to cause any interference with work of other trades, Contractor shall make the necessary changes in his/her work to correct the condition without extra charge.
 - 2. Coordinate and schedule work with other work in the same area and with work dependent upon other work to facilitate mutual progress.
- B. Coordination with controls specified in other sections or divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the contractor as follows:
 - 1. Each supplier of a controls product is responsible for the configuration, programming, start up, and testing of that product to meet the Control Sequences.
 - 2. Contractor shall coordinate and resolve any incompatibility issues that arise between control products provided under this Section and those provided under other sections or divisions of this specification.
 - 3. Contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.
 - 4. Contractor is responsible for the interface of control products provided by multiple suppliers regardless of where this interface is described within the contract documents.

3.05 WORKMANSHIP

- A. Install equipment, piping, and wiring/raceway parallel to building lines (i.e. horizontal, vertical, and parallel to walls) wherever possible.
- B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
- C. Install equipment in readily accessible locations as defined by National Electrical Code (NEC).

- D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.
 - E. All equipment, installation, and wiring shall comply with industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.
 - F. Install in accordance with Division 26.
- 3.06 FIELD QUALITY CONTROL
- A. All work, materials, and equipment shall comply with rules and regulations of applicable local, state, and federal codes.
 - B. Contractor shall continually monitor the field installation for code compliance and quality of workmanship.
 - C. Contractor shall have work inspection by local and/or state authorities having jurisdiction over the work.
- 3.07 WIRING
- A. All control and interlock wiring shall comply with national and local electrical codes, and Division 26.
 - B. Do not install Class 2 wiring in raceways containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers).
 - C. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block.
 - D. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
 - E. Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the contractor shall provide step-down transformers.
 - F. Use color-coded conductors throughout with conductors of different colors.
 - G. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.
 - H. Conceal all raceways except within mechanical, process, electrical, or service rooms. Install raceway to maintain a minimum clearance of 15 cm (6 in.) from high-temperature equipment (e.g. steam pipes or flues).
 - I. The contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.
- 3.08 SENSOR INSTALLATION
- A. Install sensors in accordance with the Manufacturer's recommendations.
 - B. Mount sensors rigidly and adequately for environment within which the sensor operates.
 - C. Room temperature sensors shall be installed on concealed junction boxes properly supported by wall framing.
 - D. Install all space temperature sensors and thermostats mounted at ADA heights.
 - E. Any temperature sensor or thermostat mounted on an exterior wall shall be mounted on a thermally insulated sub-base.
 - F. All wires attached to sensors shall be sealed in their raceways or in the wall to stop air transmitted from other areas from affecting sensor readings.
- 3.09 ACTUATOR INSTALLATION
- A. General. Mount and link control damper actuators according to Manufacturer's instructions.
 - 1. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.

2. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
 3. Provide all mounting hardware and linkages for actuator installation.
 - B. Electric/Electronic:
 1. Dampers: Actuators shall be direct mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° travel available for tightening the damper seal. Actuators shall be mounted following Manufacturer's recommendations.
- 3.10 CONTROL DAMPER INSTALLATION
- A. Damper submittals shall be coordinated for type, quantity, and size to ensure compatibility with sheet metal design.
 - B. Duct openings shall be free of any obstruction or irregularities that might interfere with blade or linkage rotation or actuator mounting. Duct openings shall measure ¼ in. larger than damper dimensions and shall be square, straight, and level.
 - C. Individual damper sections, as well as entire multiple section assemblies, must be completely square and free from racking, twisting, or bending. Measure diagonally from upper corners to opposite lower corners of each damper section. Both dimensions must be within 0.3 cm (1/8 in.) of each other.
 - D. Follow the Manufacturer's instructions for field installation of control dampers. Unless specifically designed for vertical blade application, dampers must be mounted with blade axis horizontal.
 - E. Install extended shaft or jackshaft according to Manufacturer's instructions. (Typically, a sticker on the damper face shows recommended extended shaft location. Attach shaft on labeled side of damper to that blade.)
 - F. Damper blades, axles, and linkage must operate without binding. Before system operation, cycle damper after installation to ensure proper operation. On multiple section assemblies, all sections must open and close simultaneously.
 - G. Provide a visible and accessible indication of damper position on the drive shaft end.
 - H. Support ductwork in area of damper when required to prevent sagging due to damper weight.
 - I. After installation of low-leakage dampers with seals, caulk between frame and duct or opening to prevent leakage around perimeter of damper.
- 3.11 WARNING LABELS
- A. Permanent warning labels shall be affixed to all equipment that can be automatically started by the control system.
 1. Labels shall use white lettering (12-point type or larger) on a red background.
 2. Warning labels shall read as follows:

C A U T I O N

This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to "Off" position before servicing.
- 3.12 CONTROL SEQUENCES
- A. Coordinate all power requirements with Division 26.
 - B. Venice Pump Station Temperature Control Sequences:
 1. Thermostatically Motor Operated Damper and Exhaust Fans:
 - a. Units Served:
 - 1) 100-EF-1, 100-SF-1, 100-ICD-1.
 - b. Temperature Control Contractor shall provide line voltage thermostat to be wired by Division 26, and other components as required to meet the sequence of operation.

- c. Line voltage thermostat shall monitor space temperature. Upon rise in space temperature above setpoint, 80°F, adjustable, damper actuator shall energize. Supply and exhaust fans shall turn on.
 - d. Upon satisfaction of thermostat setpoint, supply and exhaust fans shall turn off and damper actuator shall close. Wiring by Division 26.
- C. Centralia Pump Station Temperature Control Sequences:
 - 1. Thermostatically Motor Operated Damper and Exhaust Fans:
 - a. Units Served:
 - 1) Ex. EF, 300-ICD-1, 300-ICD-2.
 - b. Temperature Control Contractor shall provide line voltage thermostat to be wired by Division 26, and other components as required to meet the sequence of operation.
 - c. Line voltage thermostat shall monitor space temperature. Upon rise in space temperature above setpoint, 80°F, adjustable, both damper actuators shall energize. Exhaust fan shall turn on.
 - d. Upon satisfaction of thermostat setpoint, exhaust fan shall turn off and damper actuator shall close. Wiring by Division 26.
- D. Gray's Farm Pump Station Temperature Control Sequences:
 - 1. Thermostatically Motor Operated Damper and Exhaust Fans:
 - a. Units Served:
 - 1) 400-EF-1, 400-ICD-1.
 - b. Temperature Control Contractor shall provide line voltage thermostat to be wired by Division 26, and other components as required to meet the sequence of operation.
 - c. Line voltage thermostat shall monitor space temperature. Upon rise in space temperature above setpoint, 80°F, adjustable, damper actuator shall energize. Exhaust fan shall turn on.
 - d. Upon satisfaction of thermostat setpoint, exhaust fan shall turn off and damper actuator shall close. Wiring by Division 26.
- E. 9th Street Station Temperature Control Sequences:
 - 1. Provide NEMA 1 Temperature Control Panels (500-TCP-1). Panel shall be source for control power for HVAC control components both field (dampers, etc.) and panel installed, and shall be point of interface via hard wired connection to existing generator. Coordinate 120V power requirements with Division 26.
 - 2. Electric Unit Heaters:
 - a. Units Served:
 - 1) 500-EUH-1.
 - b. Unit heater fan and heater shall operate in response to integral thermostat. Upon fall in space temperature below initial adjustable setpoint, unit heater fan and heater shall energize. Upon satisfaction of space heating requirements, fan and heater shall stop. Provide interlock to prevent heater from running when the generator is operating.
 - 1) Electrical Room initial setpoint shall be 70°F.
 - 3. Thermostatic Exhaust Fans and Motor Operated Damper:
 - a. Units Served:
 - 1) 500-EF-1, 501-EF-1, 500-ICD-1.
 - b. Temperature Controls Contractor (TCC) shall provide temperature control panel, two thermostats, insulated control damper, damper actuator, high/low space temperature switches, and other components and wiring as required to meet the sequence of operation.

- c. Install Electrical Room space temperature switches where indicated on Plans. Upon fall in space temperature below 35°F, adjustable, low temperature alarm shall be generated. Upon rise in space temperature above 104°F, adjustable, high temperature alarm shall be generated. Alarms shall be sent to 9th Street Pump Station Monitor Panel. Interface shall be at the temperature control panel.
 - d. Each thermostat shall monitor space temperature. A call from either thermostat shall open damper. Upon rise in space temperature above setpoint, 80°F, adjustable, damper shall open, upon proof of open, respective exhaust fan shall turn on.
 - e. Upon satisfaction of thermostat setpoint, exhaust fan shall turn off. When both fans are off, damper actuator shall close.
 - f. Provide interlocks to prevent exhaust fans from running when the generator is operating.
 - 4. Generator Damper Control:
 - a. Units Served:
 - 1) 500-ICD-1, 501-ICD-1.
 - b. TCC shall provide temperature control panel, insulated control dampers, damper actuators, and other components and wiring as required to meet the sequence of operation. Coordinate wiring with Division 26.
 - c. Generator Run command received, both dampers shall open. Upon proof of open, Generator Enable command shall be sent to existing generator.
 - d. Generator Run command not received, dampers shall close.
 - e. Coordinate control of 500-ICD-1 with the operation of the exhaust fans as well.
- 3.13 FINAL ADJUSTMENT
- A. After completion of installation, adjust thermostats, motors, and similar equipment provided as work of this Section.
 - B. Final adjustment shall be performed by specially trained personnel in direct employ of manufacturer of primary temperature control system.
- 3.14 ACCEPTANCE TESTING
- A. System Acceptance: Satisfactory completion is when the Temperature Control sub-contractor has performed successfully all the required testing to show performance compliance with the requirements of the Contract Documents to the satisfaction of the Owner's Representative. System acceptance shall be contingent upon completion and review of all corrected deficiencies.
- 3.15 CLEANING
- A. Contractor shall clean up all debris resulting from his/her activities daily. Contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.
 - B. At completion of work in any area, Contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.
 - C. At completion of work, all equipment furnished under this Section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.
- 3.13 OPERATOR INSTRUCTION, TRAINING
- A. During system commissioning and at such time acceptable performance of the temperature control system has been established the Temperature Control sub-contractor shall provide on-site operator instruction to the owner's operating

personnel. Operator instruction shall be done during normal working hours and shall be performed by a competent representative familiar with the system hardware, software and accessories.

- B. The Temperature Control sub-contractor shall provide 8 hours of instruction to the Owner's designated personnel on the operation of the temperature controls and describe its intended use with respect to the programmed functions specified.

METAL DUCTS

PART 1 – GENERAL

1.01 SUMMARY

- A. Extent of ductwork is indicated on drawings and in schedules, and by requirements of this Section.
- B. Types of ductwork required for project include the following:
 - 1. Fresh air supply systems.
 - 2. Mechanical exhaust systems.

1.02 SUBMITTALS

- A. General:
 - 1. Submit Product Data in sufficient detail to confirm compliance with requirements of this Section.
- B. Product Data:
 - 1. Manufacturer's specifications for duct system materials showing thicknesses, weights, materials of construction, corrosion resistance characteristics, and method of construction.

1.03 QUALITY ASSURANCE

- A. Installer: Firm with at least 3 years successful installation experience on projects with ductwork systems work similar to that required for Project.
- B. NFPA Compliance - Comply with ANSI/NFPA 90A "Standard For The Installation Of Air- Conditioning And Ventilating Systems" and ANSI/NFPA 90B "Standard For The Installation Of Warm Air Heating And Air-Conditioning Systems".
- C. Underwriters Laboratories - UL 181 - Factory-Made Air Ducts and Connectors.
- D. Design Criteria:
 - 1. Construct all ductwork to be free from vibration, chatter, objectionable pulsations, and leakage under specified operating conditions.
 - 2. Use material, weight, thickness, gauge, construction, and installation methods as outlined in the following SMACNA publications, unless noted otherwise:
 - a. HVAC Duct Construction Standards, Metal and Flexible.
 - b. HVAC Air Duct Leakage Test Manual.
 - c. HVAC Systems - Duct Design.
 - d. Rectangular Industrial Duct Construction Standard.
 - e. Round Industrial Duct Construction Standards.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Protect shop-fabricated and factory-fabricated ductwork, accessories and purchased products from damage during shipping, storage and handling. Prevent end damage and prevent dirt and moisture from entering ducts and fittings.
- B. Where possible, store ductwork inside and protect from weather. Where necessary to store outside, store above grade and enclose with waterproof wrapping.

PART 2 – PRODUCTS

2.01 DUCTWORK MATERIALS

- A. General: All ductwork shall be constructed of non-combustible or conforming to requirements for Class 0 or 1 air duct materials, or UL 181.
- B. Exposed Ductwork Materials - Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, oil canning, stains and discolorations, and other imperfections, including those which would impair painting.

- C. Sheet Metal:
 - 1. Aluminum Sheet - ANSI/ASTM B209 aluminum sheet, alloy 3003H-14. Aluminum Connectors and Bar Stock: Alloy 6061-T6 or of equivalent strength.
- 2.02 MISCELLANEOUS DUCTWORK MATERIALS
 - A. Duct Sealant: Non-hardening, water resistant, fire resistive, compatible with mating materials; liquid used alone or with tape, or heavy mastic.
 - B. Ductwork Support Materials and Fasteners:
 - 1. Interior: Galvanized steel.
 - 2. Exterior: Type 316 stainless steel.
- 2.03 DUCTWORK COATINGS
 - A. None.
- 2.04 FABRICATION - GENERAL
 - A. Fabricate ductwork of gauges and reinforcement complying with SMACNA Duct Construction Standards and ASHRAE handbooks for 2 inWC Pressure Class.
 - B. Ductwork shall be constructed to provide the minimum clear inside dimensions indicated on the Drawings.
 - C. All ductwork specified to be of welded construction shall be a minimum 18 gauge sheet metal thickness.
 - D. Fabricate duct fittings to match adjoining ducts, and to comply with duct requirements as applicable to fittings. Except as otherwise indicated, fabricate elbows with centerline radius 1.5 times the associated duct width; and fabricate to include airfoil turning vanes in elbows where shorter radius is necessary. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fiber insulation.
 - E. Construct so that all interior surfaces are smooth. Use slip and drive or flanged and bolted construction when fabricating rectangular ductwork. Use spiral lock seam construction when fabricating round spiral ductwork. Sheet metal screws may be used on duct hangers, transverse joints and other SMACNA approved locations if the screw does not extend more than 1/2 inch into the duct.
 - F. Limit angular tapers to 30° (for contracting tapers and expanding tapers).
 - G. Provide expanded take-offs or 45-degree entry fittings for branch duct connections with branch ductwork airflow velocities greater than 700 fpm. Square edge 90-degree take-off fittings or straight taps will not be accepted.
 - H. Button punch snaplock construction will not be accepted on aluminum ductwork.
 - I. When approved by the Engineer, size round ducts installed in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular and round ducts. No variation of duct configuration or sizes permitted except by written permission.
 - J. Provide easements where low pressure ductwork conflicts with piping and structure. Where easements exceed 10 percent duct area, split into two ducts maintaining original duct area.
 - K. Use double nuts and lock washers on threaded rod supports.
 - L. Fabricate ductwork with accessories installed during fabrication to the greatest extent possible. Refer to Section 23 33 00, for accessory requirements.
 - M. Round Ductwork:
 - N. Spiral lockseam or longitudinal welded seam as manufactured by United McGill Sheet Metal Company. Models Uniseal, Unicoat, or Longitudinal Seam.
 - 1. Minimum sheet metal gauges, hanger spacing, and reinforcement shall be per SMACNA HVAC Duct Construction Standards - Metal and Flexible for pressures from negative 4 inWC up to positive 10 inWC. For pressures less than negative 4 inWC, or greater than positive 10 inWC, minimum sheet metal gauges, hanger spacing, and reinforcement shall be per SMACNA Round Industrial Duct Construction Standards.

2. Fittings: Fittings shall have a wall thickness not less than that required for longitudinal- seam straight duct.
 3. Elbows:
 - a. Elbows for round ducts shall have a minimum centerline radius of 1-1/2 times the diameter of the duct and shall be constructed without splitters.
 - b. Smooth or stamped elbows shall be used whenever possible.
 - c. When gored elbows are used they shall be constructed as follows: Elbows up to 36" shall have 2 gores, 37" through 72" shall have 3 gores, and 73" through 90" shall have 5 gores.
 - d. Four gore adjustable elbows are permitted for systems rated at 1 inWC or less. The gores shall be tack welded or coated with sealer on diameters from 8 inches to 14 inches. Diameters above 14 inches shall be tack welded.
 - O. Flat Oval Ductwork: Ductwork and fitting spiral lockseam or welded with gauges, reinforcement, and supports conforming to SMACNA Duct Construction Standards Metal and Flexible: Positive pressure applications only, up to 10 inWC. For negative pressure applications, submit special design and reinforcements required.
- 2.05 DUCT SEALANTS
- A. Manufacturers:
 1. Ductmate Industries
 2. 3M.
 3. H.B. Fuller/Foster.
 4. Or equal.
 - B. Shall be a flexible, water-based, adhesive sealant designed for use in all pressure duct systems. After curing, it shall be resistant to ultraviolet light and shall prevent the entry of water, air, and moisture into the duct system. Sealer shall be UL 723 listed and meet NFPA requirements for Class 1 ductwork. VOC shall be <75 g/l.
 - C. Select sealant color to generally match color of ductwork material.
 - D. Sealants used on ductwork indicated to receive field painting shall be suitable for painting.
 - E. Install sealants in strict accordance with manufacturer's recommendations, paying special attention to temperature limitations. Allow sealant to fully cure before pressure testing of ductwork, or before startup of air handling systems.
- 2.06 GASKETS
- A. For 2-inWC Pressure Class and lower, provide soft neoprene or butyl gaskets in combination with duct sealant for flanged joints.

PART 3 – EXECUTION

- 3.01 INSTALLATION OF DUCTWORK
- A. Provide ductwork insulation in accordance with Section 23 07 00.
 - B. Assemble and install ductwork to achieve SMACNA seal Class B and noiseless (no objectionable noise) systems. Install each run with minimum of joints.
 - C. A rigid ductwork support or form of lateral bracing shall be provided at each change in ductwork directions, each end of run and elsewhere as noted on Drawings to minimize ductwork sway to no more than 1/2-inch of total travel.
 - D. Pittsburgh lock seams and slip joints or ductmate shall be used for all rectangular ducts.
 - E. Align ductwork accurately at connections, within 1/8-inch misalignment tolerance and with internal surfaces smooth.
 - F. Coordinate ductwork layout with lighting, suspended ceilings, piping, and structural components.

- G. Locate ductwork runs, except as otherwise indicated, vertically and horizontally and avoid diagonal runs wherever possible.
- H. Locate runs as indicated by diagrams, details, and notations. Ensure ductwork does not obstruct usable space or block access for servicing building and its equipment.
- I. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building. Limit clearance to ½-inch where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any. Where possible, locate insulated ductwork for 1-inch clearance outside of insulation.
- J. Pitch outside air intake ductwork toward intake to allow drainage to building exterior.
- K. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pitot tube openings where required for testing of systems, complete with metal cap with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
- L. Where ducts pass through interior partitions and exterior walls, conceal space between construction opening and duct or duct-plus-insulation with sheet metal flanges of same gauge and material as duct. Overlap opening on 4 sides by at least 1-1/2 inches.
- M. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire damper, sleeve, and fire-stopping sealant.
- N. Coordinate duct installations with installation of accessories, dampers, equipment, controls and other associated work of ductwork system.
- O. Sealants:
 - 1. Shall be pumped or painted into joints, as required, after assembly.
 - 2. All tie bars, bolts and rivets shall be sealed with the specified sealant.
 - 3. Install sealants in strict accordance with manufacturer's recommendations, paying special attention to temperature limitations.
 - 4. All sealant surfaces shall be brushed, troweled, or wiped smooth resulting in no ridges, peaks, or other surface irregularities that result in application thickness greater than manufacturers recommended or more than 50% thicker than adjacent material.
 - 5. Allow sealant to fully cure before pressure testing of ductwork, or before startup of air handling systems.
- P. All ductwork shall be airtight before concealment and/or before insulation is applied.
- Q. All tie rods shall be 3/8-inch diameter. When one tie rod is required, it shall be installed in the center of the duct. When two tie rods are required, installation shall be at 1/3 points across ducts. When three tie rods are required, installation shall be at 1/4 points across ducts. Where tie rods are required in the horizontal and vertical side, they shall be welded together where they cross. All tie rods shall be welded to reinforcing angles or joints.
- R. Install concrete inserts for support of ductwork in coordination with formwork.
- S. Support ductwork in manner complying with SMACNA "Duct Construction Standards - Metal and Flexible"- Latest Edition hangers and supports section.
- T. Where dissimilar metals meet, provide positive electric isolation using insulating material, sealants, and fasteners.
- U. Unless specifically indicated on Drawings or DUCTWORK COATING paragraph, ductwork systems shall not be painted or coated.

3.02 DUCT OBSTRUCTIONS

- A. Install streamlined metal sleeve around any obstruction which must run through ducts with approval by the Engineer only.
 - B. Sleeves to have rounded noses on upstream face and tapered back to point on downstream side of obstructions. Sleeves to extend completely between walls of duct and be firmly riveted in place.
- 3.03 PIPE SEALS
- A. All openings around pipes thru sheet metal ducts, casings, or other sheet metal surfaces shall be sealed and made airtight by this Contractor.
 - B. Seal shall consist of ¼ inch thick split felt gasket tightly fitted around pipe and held in place with either a split rigid steel ring or a Crane No. 20 chrome-plated split floor plate drilled and bolted to the sheet metal surface.
- 3.04 INSTALLATION OF AUTOMATIC DAMPERS
- A. Install all automatic dampers furnished by and under the supervision of the automatic temperature control manufacturer.
 - B. All blank-off plates and conversions necessary to install smaller than duct size dampers shall be the responsibility of the ductwork installer.
 - C. The Temperature Controls Contractor, as work of Section 23 09 23, shall submit a schedule of damper sizes to the ductwork installer, with a copy to the Engineer.
- 3.05 LOUVERS AND BLANK-OFF PANELS
- A. Outdoor air intake and exhaust louvers are specified under other sections. Where ductwork indicated to be connected to louver, provide 1-1/2" x 1-1/2" x 1/4" galvanized steel angle frames all around the louver openings securely bolted to construction with mastic caulking compound between angle and construction. Ductwork, casings, etc., shall be riveted to the outstanding leg of angle frames.
 - B. Blank-off panels, where required, shall be provided under this Section of the Specifications. Panels shall be of double wall aluminum construction with central layer of 2-inches thickness of polyisocyanurate board insulation.
 - C. Where louvers contain gravity or motor operated dampers and are shown to be non-ducted, provide No. 2 (1/2-inch mesh) 0.063-inch diameter aluminum bird screens with rewirable and removable extruded aluminum frames or aluminum expanded metal on the interior face of damper installed to not interfere with damper operation.
- 3.06 CAULKING AND TAPING
- A. Caulk all joints, rivets, flanges, flexible connections, filter frames, openings, seams, etc.
 - B. Caulk all casings airtight.
 - C. Caulking shall be 3M No. EC-800 premium grade.
 - D. Where pressure testing indicates a leak that caulking has not sealed, provide a sheet metal jacket over the seam or joint and weld in place. Weldments to be continuous.
- 3.07 CLEANING AND PROTECTION
- A. Clean ductwork internally, unit-by-unit as it is installed, of dust and debris. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or, where ductwork is to be painted, might interfere with painting or cause paint deterioration.
 - B. At ends of ducts which are not connected to equipment or any distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.

NON-FIBROUS CLOSED-CELL, OUTDOOR DUCTWORK

PART 1 – GENERAL

1.01 SUMMARY

A. Section Includes:

1. Factory insulated, outdoor ductwork systems.

1.02 SUBMITTALS

A. General:

1. Submit Product Data in sufficient detail to confirm compliance with requirements of this Section. Submit Product Data and Shop Drawings in one complete submittal package. Partial submittals are unacceptable.
- B. Product data:** For each type of product indicated.
- C. Shop drawings:** Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work including.
1. Duct layout indicating sizes and pressure classes.
 2. Elevation of top of ducts.
 3. Dimensions of main duct runs from building grid lines.
 4. Fittings.
 5. Penetrations through fire-rated and other partitions.
- D. Coordination Drawings:** Plans, drawn to scale, showing coordination general construction, building components, and other building services.
- E. Manufacturer's field installation inspection report.**

1.03 QUALITY ASSURANCE

- A. Manufacturer Qualifications:** Firms experienced in manufacturing phenolic ductwork systems meeting the requirement of SMACNA's Phenolic Duct Construction Standard for no less than 3 years.

1.04 PRODUCT DELIVERY AND STORAGE

- A. Prevent objectionable aesthetic damage to the outer surface of duct segments during transport and storage.**
- B. Store duct segments under cover and protect from excessive moisture prior to installation.**

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver components to their final locations in protective wrappings, containers, and other protection that will exclude dirt and moisture and prevent damage from construction operations. Remove protection only after equipment is made safe from such hazards.**

PART 2 – PRODUCTS

2.01 RECTANGULAR DUCT AND FITTINGS

A. MANUFACTURERS

1. Thermaduct.
2. Or equal.

B. Requirements:

1. Fabricated to a minimum 2 inWC Pressure Class.
2. Duct Leakage Class, follow SMACNA Leakage Class 3 or less.
3. Fortified inner liner shall be compliant to UL (C-UL) 181 Standard for Safety Listed, Class 1 system, with included testing and passing the following:
 - a. Test for Surface Burning Characteristics
 - b. Flame Penetration Test

- c. Burning Test
 - d. Mold Growth and Humidity Test
 - e. Low Temperature Test and High Temperature Test
 - f. Puncture Test
 - g. Static Load Test
 - h. Impact Test
 - i. Pressure Test and Collapse (negative pressure) Test
 - j. High Temperature and Humidity for 90 days
 - k. Cone Calorimeter
 - l. ASTM E2257 Standard Test Method for Room Fire Test of Wall and Ceiling Materials and Assemblies
 - m. ASTM E 84 tested, Tunnel Test, Does not exceed 25 flame spread, 50 smoke developed.
 - n. DW144, Class B
 - o. NRTL product approval, (Subpart S of 29 CFR Part 1910, OSHA)
 - p. ASTM C 423 noise reduction
 - q. ASTM E 96/E 96M Procedure A for permeability
 - r. ASTM C 1071 for erosion
 - s. ASTM C 518: 2004, Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
 - t. UL 723, Test for Surface Burning Characteristics of Building Materials
 - u. NFPA Compliance:
 - 1) NFPA 90A, "Installation of Air Conditioning and Ventilating Systems"
 - 2) NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems"
 - 3) NFPA 255, "Standard Method of Test of Surface Burning Characteristics of Building Materials"
4. Outer shell shall be a UV stable 1000-micron high impact resistant titanium infused vinyl with included testing as following:
- a. UL-94 Flammability V-0
 - b. ASTM D-638 Tensile Strength of 6250 psi
 - c. ASTM D-790 Flexible Strength of 11,000 psi
 - d. ASTM D-4226 Drop Impact Resistance
 - e. ASTM D-4216 Cell Classification
- C. Construction:
- 1. Duct wall panel shall be manufactured of CFC-free closed cell rigid thermoset resin (Kingspan Kooltherm, or equal) thermally bonded on both sides to a factory applied 0.001 inches (25 micron) aluminum foil facing reinforced with a fiberglass scrim.
 - 2. Include UV stable, IR reflective 1000-micron high impact resistant titanium infused vinyl, factory bonded to panel exterior using a full lamination process. Lamination process shall permanently bond the vinyl clad to the outer surfaces of the phenolic foam panel to provide a zero-permeability water tight barrier and to form a structurally insulated panel (SIP) in which to form duct segments.
 - a. Processes that do not employ a full lamination process are not acceptable.
 - b. Self-applied adhesives such as tapes, caulks or cladding that incorporate pressure sensitive or spray adhesives are not acceptable.
 - 3. Thermal conductivity shall be no greater than 0.13 BTU•in/(hr•ft²•°F) (0.018W/(m•°C)) at 75°F mean temperature.
 - 4. Density of foam shall not be less than 3.5 lb/ft³ (56 kg/m³) with a minimum compressive strength of 28 psi (0.2 MPa).

5. Panel shall have:
 - a. Continuous rating of 185°F (70°C) inside ducts or ambient temperature surrounding ducts.
 - b. Permeability: 0.00 perms maximum when tested according to ASTM E 96/E 96M, Procedure A.
 - c. Antimicrobial Agent: Additive for antimicrobial shall not be used but instead, raw product must pass UL bacteria growth testing.
 - d. Noise-Reduction Coefficient: 0.05 minimum when tested according to ASTM C 423, Mounting A.
 - e. All interior duct liner shall bear UL label and other markings required by UL 181 on each full sheet of duct panel; UL ratings for internal closure materials.
 - f. All insulation materials shall be closed cell with a closed cell content of >90%.
 - g. R-value:
 - 1) 1-3/4 inch (45 mm) Thick Panel: 12 R
 6. Closure Materials:
 - a. V-Groove Adhesive: Silicone (interior only).
 - b. UV stable 1000 micron high impact resistant titanium infused vinyl (exterior).
 - 1) Factory manufactured seamless corners for zero perms.
 - 2) Cohesive bonded over-lap at corner seam covers for zero perms.
 - 3) Water resistant titanium infused welded vinyl seams.
 - 4) Mold and mildew resistant.
 - c. Polymeric Sealing System:
 - 1) Structural Membrane: Aluminum scrim with woven glass fiber with UV stable vinyl clad applied
 - 2) Minimum Seam Cover Width: 2-7/8" inches (75 mm)
 - 3) Sealant: Low VOC.
 - 4) Color: White (colors, matched by architect optional).
 - 5) Water resistant.
 - 6) Mold and mildew resistant.
 - d. Duct Connectors:
 - 1) Factory manufactured cohesive bonded strips (low pressure only).
 - 2) Factory manufactured all aluminum grip flange.
 - 3) Factory manufactured galvanized 4-bolt flange.
 7. Outdoor Cladding:
 - a. Duct segments shall incorporate UV stable 1000 micron high impact resistant titanium infused vinyl which is introduced during the manufacturing process.
 8. Flange Coverings:
 - a. Flanges are field sealed airtight before flange covers are installed. Flange covering consists of the following:
 - 1) Foam tape insulation with molded 39 mil covers.
 - 2) Air gap (heating only application) with molded 39 mil covers.
- 2.02 DUCTWORK SUPPORT SYSTEMS:
- A. Provide meeting requirements of duct system Manufacturer, Section 23 31 13.
 - B. All support components shall be fabricated of 316 stainless steel.

PART 3 – EXECUTION

3.01 EXAMINATION

- A. Contractor shall examine proposed installation location and confirm all required dimension for Manufacturer.
- B. Coordinate all work with installation work of other trades.

3.02 SHOP FABRICATION

A. Certification:

1. Ducts shall be detailed and fully factory manufactured at a facility authorized by system Manufacturer. All fabrication labor shall be certified "yellow label" building trade professionals, compliant to SMWIA and SMACNA labor guidelines (work preservation observed).

B. Fabrication:

1. Fabricated joints, seams, transitions, reinforcement, elbows, branch connections, access doors and panels, and damage repairs according to manufacturer's written and detailed instructions.
2. Fabricated 90-degree mitered elbows to include turning vanes.
3. Fabricated duct segments in accordance with manufacturer's written details.
4. Duct Fittings shall include 6 inches of connecting material, as measured, from last bend line to the end of the duct. Connections on machine manufactured duct may be 4 inches.
5. Fabricated duct segments utilizing v-groove method of fabrication. Factory welded or cohesively bonded seams will apply to fully manufactured ductwork and fittings. Internal seams will be supplied with an unbroken layer of low VOC silicone or bonding (for paint shop applications). Each duct segment will be factory supplied with either aluminum grip pro-file or pre-insulated duct connectors in accordance with manufacturer's detailed submittal guide. Applied duct reinforcement to protect against side deformation from both positive and negative pressure per manufacturer's design guide based on specified ductwork size and system pressure.
6. Designed and fabricated duct segments and fittings will be in accordance with "SMACNA Duct Construction Standards" latest edition.
7. Both positive and negative ductwork and fittings shall be constructed to incorporate a UL Listed as a Class 1 air duct to Standard for Safety UL 181 liner with an exterior clad for permanent protection against water intrusion.
8. Duct shall be constructed to exceed requirements for snow and wind loads.

3.03 DUCT INSTALLATION

A. Duct segments shall be installed by Contractor with licensed HVAC installers.

B. Install ducts and fittings to comply with Manufacturer's installation instructions as follows:

1. Install ducts with fewest possible joints.
2. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
3. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
4. Protect duct interiors from the moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."
5. Use prescribed duct support spacing as described in this specification and manufacturer's recommendations.

C. Air Leakage: Duct air leakage rates to be in compliance with "SMACNA HVAC Duct Construction Standards" latest version per applicable leakage class based on pressure.

3.04 HANGERS AND SUPPORT INSTALLATION

A. Contractor to ensure that the ductwork system is properly and adequately supported.

1. Ensure that the chosen method is compatible with the specific ductwork system requirements per Manufacturer's installation detail drawings. Pre-installation

should be provided prior to work commencement by installing contractor for approval.

2. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 - B. Supports on straight runs of ductwork shall be positioned at centers not exceeding 13 feet (3.96 m) for duct sections when fabricated in 13 foot (3.96 m) lengths with duct girth less than 84". Larger duct sizes and short segments with duct girth greater than 84" are to be supported at 8 foot centers or less, in accordance with the Manufacturer's installation details provided prior to work commencement.
 - C. Ductwork shall be supported at changes of direction, at branch duct connections, tee fittings, parallel under turning vanes and all duct accessories such as dampers, etc.
 - D. The load of such accessories to the ductwork shall be neutralized by the accessory support.
- 3.05 FIELD QUALITY CONTROL
- A. Inspection: Arrange for Manufacturer's representative to inspect completed installation and provide written report that installation complies with manufacturer's written instructions
 1. Remove and replace duct system where inspection indicates that it does not comply with specified requirements.
 - B. Perform additional testing and inspecting, at the Contractor's expense, to determine compliance of replaced or additional work with specified requirements.

AIR DUCT ACCESSORIES

- 1.01 DESCRIPTION OF WORK
- A. Extent of duct accessories work is indicated on drawings and in schedules, and by requirements of this section.
 - B. Types of duct accessories required for project include the following:
 1. Manual Dampers.
 2. Barometric Backdraft Dampers (BDD).
 3. Turning Vanes.
 4. Duct Hardware.
 5. Duct Access Doors.
 6. Flexible Connections.
 7. Fire Dampers.
 8. Differential Pressure Gauges.
 9. Filter Housing.
 10. Filter Frame.
 - C. Provide seismic restraints in accordance with Section 40 05 08.
- 1.02 QUALITY ASSURANCE
- A. SMACNA Compliance - Comply with applicable portions of Sheet Metal and Air Conditioning Contractor's National Association (SMACNA) "Duct Construction Standards - Metal and Flexible"
 - B. NFPA Compliance - Comply with applicable provisions of ANSI/NFPA 90A "Air Conditioning and Ventilating Systems", pertaining to installation of duct accessories.
- 1.03 SUBMITTALS
- A. General:

1. Submit Product Data in sufficient detail to confirm compliance with requirements of this Section.
 - B. Product Data:
 1. Manufacturer's specifications for duct system materials showing thicknesses, weights, materials of construction, corrosion resistance characteristics, and method of construction.
- 1.04 MAINTENANCE
- A. Extra Materials:
 1. Furnish extra materials matching products installed, as described below, packaged with protective covering for storage, and identified with labels describing contents.
 - a. Two (2) sets of filters for each unit requiring filters (one for construction and one for final completion).

PART 2 – PRODUCTS

- 2.01 RECTANGULAR MANUAL BALANCING DAMPERS
- A. Provide dampers of single blade type or multiblade type, constructed in accordance with SMACNA Standards. Dampers greater than 10-inch height shall be multiblade type.
 - B. 304 stainless steel frame and damper blade with 20-gage blade stop.
 - C. 1/2-inch hex axle with molded synthetic bearings.
 - D. All dampers shall be furnished with locking hand quadrant. Dampers installed on insulated duct systems shall be furnished with extended quadrant.
 - E. Manufacturer - Subject to compliance with requirements, provide dampers of one of the following:
 1. Ruskin model MD35.
 2. Or equal.
- 2.02 BAROMETRIC BACKDRAFT DAMPERS
- A. Standard Backdraft Dampers:
 1. Parallel blade, counterbalanced, adjustable backdraft damper.
 2. Provide in vertical or horizontal configuration as required by installation location.
 3. Aluminum frame and blade construction with vinyl blade seals.
 4. Units installed in electrical rooms shall be set for 0.05 beginning pressure relief.
 5. Manufacturer – Subject to compliance with requirements, provide dampers of one of the following:
 - a. Greenheck model BR.
 - b. Or equal.
- 2.03 TURNING VANES
- A. Provide turning vanes constructed of curved blades supported with bars perpendicular to blades and set into side strips suitable for mounting in ductwork.
 - B. Turning vanes installed in aluminum ductwork shall be of aluminum construction.
 - C. Manufacturer - Subject to compliance with requirements, provide turning vanes of one of the following:
 1. Cain Mfg Co.
 2. Tuttle & Bailey.
 3. Or equal.
- 2.04 DUCT HARDWARE
- A. Quadrant Locks: Provide for each damper, quadrant lock device on one end of shaft; and end bearing plate on other end for damper lengths over 12". Provide extended quadrant locks and end extended bearing plates for externally insulated ductwork.

- B. Manufacturers - Subject to compliance with requirements provide duct hardware of one of the following:
 - 1. Ventfabrics, Inc.
 - 2. Young Regulator Co.
 - 3. Or equal.
- 2.05 DUCT ACCESS DOORS
- A. Construct of same or greater gauge as ductwork served, provide insulated doors for insulated ductwork. Access doors shall be constructed of same material as the duct system served.
 - B. Provide flush frames for uninsulated ductwork, extended frame for externally insulated duct.
 - C. Provide one side hinged, other side with 1 handle-type latch for doors 12" high and smaller, 2 handle-type latches for larger doors.
 - D. Provide access doors on exhaust systems upstream of all elbows with turning vanes and upstream of electric heating coils.
 - E. Manufacturers - Subject to compliance with requirements provide duct access doors of one of the following:
 - 1. Ruskin Mfg. Co.
 - 2. Ventfabrics, Inc.
 - 3. Or equal.
- 2.06 FLEXIBLE CONNECTIONS
- A. Provide flexible duct connections wherever ductwork connects to vibration isolated equipment.
 - B. Construct flexible connections of neoprene-coated flameproof fabric crimped into duct flanges for attachment to duct and equipment. Make airtight joint.
 - C. Provide adequate joint flexibility to allow for thermal, axial, transverse, and torsional movement, and also capable of absorbing vibrations of connected equipment.
 - D. Manufacturers - Subject to compliance with requirements provide flexible connections of one of the following:
 - 1. Ventfabrics.
 - 2. Or equal.
- 2.07 FIRE DAMPERS
- A. Manufacturers:
 - 1. Greenheck.
 - 2. Louvers and Dampers, Inc.
 - 3. Ruskin.
 - 4. Or equal.
 - B. Provide curtain type fire dampers of sizes as shown on Drawings.
 - C. All fire dampers shall have a 1-1/2 or 3-hour fire rating as indicated on Plans.
 - D. Constructed casing of 11-ga. 304 stainless steel.
 - E. Provide with fusible link rated at 160°F to 165°F.
 - F. Provide damper with positive lock in closed position.
 - G. Curtain in airstream.
- 2.08 DIFFERENTIAL PRESSURE GAUGE
- A. Manufacturer
 - 1. Dwyer.
 - 2. Or Equal.
 - B. Service: Air.
 - C. Housing: Die cast aluminum case and bezel, with acrylic cover. Exterior finish is coated gray to withstand 168 hour salt spray corrosion test.
 - D. Pressure Limits: 0-0.5"w.c.

2.09 E. Accuracy: +/- 3%
FILTER HOUSING

- A. Manufacturer:
1. AAF Flanders, SureFlo.
 2. Or equal.
- B. Construction:
1. Minimum 16 gage galvanized steel frame.
 2. "Z" channel support members reinforced all four corners.
 3. All tracks and doors to be fully gasketed.
 4. Holding frames or fasteners shall not be required.
 5. Double-wall insulation on doors.
 6. Suitable for 2" deep filters.
- C. Schedule:

Location	Quantity	Housing Size Code	Filters
200 – Bowman Pump Station	2	10W x 15H	Three (3) 24"x24"x2", disposable glass- fiber pleated media filters. ASHRAE 52.2 MERV 8. Maximum initial pressure drop of 0.24-in. w.c. at 500 fpm face velocity. American Air Filter (AAF) PerfectPleat 2", or equal.
500 – 9th Street Pump Station Electrical Room	1	30W x 25H	Fifteen (15) 24"x24"x2", disposable glass-fiber pleated media filters. ASHRAE 52.2 MERV 8. Maximum initial pressure drop of 0.24-in. w.c. at 500 fpm face velocity. American Air Filter (AAF) PerfectPleat 2", or equal.

FILTER FRAME

- A. Manufacturer:
1. AAF Flanders.
 2. Or equal.
- B. Frame size per Plans.
- C. Construction:
1. Galvanized steel frame.
 2. Frames shall be modular and be capable of bolting together.
 3. Gasketed frame to create a seal at the filter frame.
 4. Provide (4) latches per frame that do not interfere with filter seal.
 5. Latches to be secure and rotatable for filter removal.
- D. Filters:
1. Quantity and size per Plans.
 2. 2-inch thick, disposable glass-fiber pleated media filters. ASHRAE 52.2 MERV 8. Maximum initial pressure drop of 0.24-in. w.c. at 500 fpm face velocity. American Air Filter (AAF) PerfectPleat 2", or equal.

PART 3 – EXECUTION

1.01 INSPECTION

- A. Examine areas and conditions under which duct accessories will be installed. Do not proceed with work until unsatisfactory conditions have been corrected.
- 1.02 INSTALLATION
 - A. Install duct accessories in accordance with manufacturer's installation instructions, with applicable portions of details of construction as shown in SMACNA standards.
 - B. Install turning vanes in square or rectangular 90° elbows in supply and exhaust air systems, and elsewhere as indicated.
 - C. Install access doors to open against system air pressure, with latches operable from either side, except outside only where duct is too small for person to enter. Install access doors where indicated and at each control damper.
 - D. Coordinate with other work, including ductwork, as necessary to interface installation of duct accessories properly with other work.
- 1.03 FIELD QUALITY CONTROL
 - A. Operate installed duct accessories to demonstrate compliance with requirements.
 - B. Test for air leakage while system is operating.
 - C. Repair or replace faulty accessories, as required to obtain proper operation and leakproof performance.

HVAC POWER VENTILATORS

PART 1 – GENERAL

- 1.01 SUMMARY
 - A. This section identifies power ventilators to be furnished and installed as shown on HVAC drawings and schedules and as specified herein. Power ventilators required for this project include:
 - 1. Centrifugal wall ventilators.
 - 2. Centrifugal inline fans.
 - 3. Axial wall ventilators.
 - 4. Electronically commutated motors (ECM)
 - B. The following is not work of this section, refer to Division 26.
 - 1. Power supply wiring from power source to power connection on ventilators. All components required to make a complete installation shall be provided, including but not limited to starters, disconnects and required electrical devices. Electrical equipment specified to be furnished or factory installed by Manufacturer shall be provided under this Section in accordance with Division 26.
 - C. Control and interlock wiring between ventilators and field installed devices shall be work of Section 23 09 23, installed in accordance with Division 26. Interlock and control wiring specified as factory installed is work of this Section.
- 1.02 DEFINITIONS, ABBREVIATIONS AND ACRONYMS
 - A. Acronyms:
 - 1. CCW: Counterclockwise
 - 2. CW: Clockwise
 - 3. ODP: Open Drip Proof
 - 4. TEFC: Totally Enclosed Fan Cooled
 - B. Unit Abbreviations:
 - 1. CFM: Cubic Feet per Minute
 - 2. FLA: Full Load Amps
 - 3. RPM: Revolutions per Minute
 - 4. V: Volts

1.03 REFERENCES

A. Standard References:

1. AMCA: Air Movement and Control Association
2. NEMA: National Electrical Manufacturers Association
3. NRCA: National Roofing Contractors Association
4. UL: Underwriters Laboratories Incorporated

1.04 SUBMITTALS

A. General:

1. Submit Product Data in sufficient detail to confirm compliance with requirements of this Section. Submit Product Data and Shop Drawings in one complete submittal package. Partial submittals are unacceptable.

B. Product Data:

1. Catalog cuts and product specifications for ventilators specified.
2. Capacity curve or chart with specified operating point clearly identified.
3. List of furnished accessories and accompanying accessory data including tabulation of accessory pressure drops.

C. Shop Drawings:

1. Installation and assembly drawings and specifically prepared technical data for ventilators.
2. Equipment dimension and weights.
3. Wiring Diagrams: Show power and control connections and distinguish between factory-installed and field-installed wiring.

D. Operation and Maintenance (O&M) Data:

1. Operating instructions and maintenance data for materials and products for inclusion in O&M Manual.
2. Manufacturer's written instructions for periodic tests of ventilators in service.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: Provide power ventilators from firms regularly engaged in manufacture of power ventilators of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.

B. Regulatory Requirements:

1. AMCA Compliance - Provide power ventilators which have been tested and rated in accordance with AMCA standards, and bear AMCA Certified Ratings Seal.
2. UL Compliance - Provide power ventilators which are designed, manufactured, and tested in accordance with UL 705 "Power Ventilators".
3. NEMA Compliance - Provide motors and electrical accessories complying with NEMA standards

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver ventilators to their final locations in protective wrappings, containers, and other protection that will exclude dirt and moisture and prevent damage from construction operations. Remove protection only after equipment is made safe from such hazards.

B. Store ventilators in clean, dry location.

1.07 MAINTENANCE

A. Extra Materials:

1. Furnish extra materials matching products installed, as described below, packaged with protective covering for storage, and identified with labels describing contents.
 - a. Furnish a minimum of two spare sets of filters for all ventilators scheduled or specified to be furnished with replaceable filters.

PART 2 – PRODUCTS

2.01 CENTRIFUGAL WALL VENTILATORS

- A. Manufacturers:
 - 1. Greenheck.
 - 2. Carnes Company.
 - 3. Cook Company.
 - 4. Or equal.
- B. Type: Provide hooded dome or upblast type centrifugal wall ventilators of types, sizes, direct or belt-driven and capacities as shown on drawings or schedules.
- C. Construction: Fan and motor housing shall be constructed of aluminum, fan hood shall be beaded or internally supported for rigidity. Fans shall be provided with pre-punched square mounting plate for mounting to wall. Up-blast type fans shall be provided with drain for the wind band. Drive assembly shall be isolated from fan plate to reduce vibration and noise transmission.
- D. Wheel, Shaft and Drive: Fan wheel shall be backward inclined non-overloading or forward curved as noted above. Bearings shall be heavy-duty pillow block bearings selected for minimum life of 100,000 hours at maximum rated speed of the fan. Drives shall be sized for a minimum of 150% of installed motor horsepower. Sheaves shall be of cast iron construction. Motor sheaves shall be adjustable for system balancing. Fans shall be dynamically and statically balanced and tested before shipment. Fans scheduled to be of spark resistant construction shall be constructed of non-ferrous materials in accordance with AMCA Type B Spark Resistant Construction.
- E. Electrical: Provide factory-wired, fusible type disconnect switch in accordance with Division 26. Fans designated to be of spark-resistant construction and provided with explosion-proof motors shall be provided with a factory wired disconnect switch suitable for the environment in which it is installed and wired in accordance with Division 26.
- F. Motors: Provide TEFC motors for all belt drive fans unless specified to be explosion proof, ODP for direct drive fans. Provide motors of scheduled horsepower in accordance with Division 26. Provide motors of scheduled horsepower in accordance with Division 26, EC motors and integral VFD motors shall be provided in accordance with applicable paragraphs of this Section.
- G. Accessories: Provide fans with the following accessories and as scheduled:
 - 1. Dampers: Provide motor operated or gravity actuated dampers as scheduled. Motor operated damper shall meet the requirements of Section 23 09 23. Gravity actuated dampers shall meet the requirements of Section 23 33 00.
 - 2. Birdscreen: Provide manufacturer's standard aluminum birdscreen.
 - 3. Speed Control Dial: For all direct drive ventilators, provide speed control, solid state, capable of controlling fan speed from full speed to approximately half speed. Install near fan for balancing purposes only.

2.02 CENTRIFUGAL INLINE FANS

- A. Manufacturers:
 - 1. Greenheck.
 - 2. Carnes Company.
 - 3. Cook Company.
 - 4. Or equal.
- B. Type: Inline centrifugal exhaust ventilator.
- C. Construction: Fan housing shall be constructed of aluminum. Fan wheel shall be backward inclined, non-overloading of aluminum construction. Drives shall be sized for a minimum of 150% of driven horsepower.

- D. Motors: Provide TEFC motors for all belt drive fans unless specified to be explosion proof, ODP for direct drive fans. Provide motors of scheduled horsepower in accordance with Division 26. Provide motors of scheduled horsepower in accordance with Division 26, EC motors and integral VFD motors shall be provided in accordance with applicable paragraphs of this Section.
- E. Electrical: Provide factory-wired, fusible type disconnect switch in accordance with Division 26. Fans designated to be of spark-resistant construction and provided with explosion-proof motors shall be provided with a factory wired disconnect switch suitable for the environment in which it is installed and wired in accordance with Division 26.
- F. Accessories: Provide fans with the following accessories:
 - 1. Inlet and discharge collars.
 - 2. Sloped filter box.
 - a. Four (4) 20"x20"x2", disposable glass-fiber pleated media filters. ASHRAE 52.2 MERV 13. Maximum initial pressure drop of 0.30-in. w.c. at 500 fpm face velocity. American Air Filter (AAF) PREpleat M13, or equal.
 - 3. Vibration isolation kit for horizontal hanging installation.
 - 4. Insulated fan housing.
 - 5. Inline and side discharge, see Plans for orientation.
 - 6. Outlet guard(s).

2.03 AXIAL WALL FANS

- A. Manufacturers:
 - 1. Greenheck.
 - 2. Carnes Company.
 - 3. Cook Company.
 - 4. Or equal.
- B. Type: Axial flow, direct or belt driven propeller fan as scheduled.
- C. Construction: Fan panel shall be single piece construction of galvanized or painted steel with deep formed inlet venturi and pre-punched mounting holes. Drive support frame shall be of heavy gauge steel construction.
- D. Wheel, Shaft and Drive: Propeller shall be constructed of cast aluminum blades securely fastened to cast hub. Hub shall be keyed to ground and polished shaft. Bearings shall be heavy-duty pillow block bearings selected for minimum life of 100,000 hours at maximum rated speed of the fan. Drives shall be sized for a minimum of 150% of installed motor horsepower. Sheaves shall be of cast iron construction, motor sheaves shall be adjustable for system balancing. Fans shall be dynamically and statically balanced and tested before shipment.
- E. Electrical: Provide factory-wired, fusible type NEMA 4X disconnect switch in accordance with Division 26.
- F. Motors: Provide TEFC motors of scheduled horsepower in accordance with Division 26. Provide motors of scheduled horsepower in accordance with Division 26, EC motors and integral VFD motors shall be provided in accordance with applicable paragraphs of this Section.
- G. Finish: Factory applied prime and finish coatings in manufacturer's standard corrosion resistant paint.
- H. Accessories: Provide fans with the following accessories as scheduled:
 - 1. Dampers: Provide motor operated or gravity actuated dampers as scheduled. Motor operated damper shall meet the requirements of Section 23 09 23. Gravity actuated dampers shall meet the requirements of Section 23 33 00.

2. Wall Housing: Provide manufacturer's standard wall housing for scheduled fan size. Housing shall be constructed of galvanized steel with pre-punched mounting holes. Provide housing with motor side guard of welded steel wire construction.
 3. Provide special coatings as scheduled.
 4. Weatherhood: Provide manufacturer's standard weatherhood constructed of galvanized steel with insect screen. Provide weatherhood with painted finish, final color to be selected to match color of existing louvers.
 5. OSHA guard.
- 2.04 ELECTRONICALLY COMMUTATED MOTORS (ECM)
- A. Provide EC Motors for individual fans when scheduled.
 - B. Specifically designed for fan applications.
 - C. AC induction type motors are not acceptable, including:
 1. Shaded Pole
 2. Permanent Split Capacitor (PSC)
 3. Split Phase
 4. Capacitor Start
 5. 3 phase induction type motors.
 - D. Permanently lubricated with heavy-duty ball bearings to match the fan load.
 - E. Prewired to the scheduled voltage and phase.
 - F. Internal motor circuitry shall convert AC power supplied to the fan to DC power to operate the motor.
 - G. Motor shall be speed controllable down to 20% of full speed (80% turndown).
 - H. Motor shall be a minimum of 85% efficient at all speeds
 - I. Speed shall be controlled by one of the following methods as indicated in the Schedules. For all methods, motor shall at a minimum include a 24v power supply capable of powering all included controller and a normally open contact rated at no less than 6 amps at 250 Vac and 5 amps at 30Vdc, unless indicated otherwise. Contact shall close when fan is running and shall be capable of operating an associated motor operated damper.
 1. Manual Dial: Provide potentiometer dial mounted on the motor for local speed adjustment.

PART 3 – EXECUTION

3.01 EXAMINATION

- A. Examine areas and conditions under which power ventilators are to be installed. Do not proceed with installation until unsatisfactory conditions are corrected.

3.02 GENERAL

- A. Install all equipment in accordance with manufacturer's installation instructions, industry standards, local Mechanical Code and as indicated in this section and on the Drawings.
- B. Coordinate installation with electrical work for power wiring to each piece of powered equipment.

3.03 INSTALLATION

- A. Axial Wall Fans:
 1. Coordinate installation of axial wall fans with work of walls as necessary for proper interfacing.
 2. Provide ductwork transition as shown or as required to connect fan to louver and wall. Construct transition of heavy enough gauge material to support fan. Where it is not practical to support fan with transition, support fan from above with contractor designed rigid steel supports, not threaded rods.

3. Remove shipping bolts and temporary supports within ventilators. Adjust dampers for free operation.
- B. Ventilators:
 1. Coordinate installation of power ventilators with work of roofing, walls and ceiling as necessary for proper interfacing.
 2. Connect ductwork to roof ventilators as shown and in accordance with manufacturer's installation instructions. Solder bottom joints and up 2-inches of side joints of duct under roof ventilator to retain any moisture entering ventilator.
 3. Remove shipping bolts and temporary supports within power ventilators. Adjust dampers for free operation.
- C. Roof Curbs:
 1. Curbs furnished under this section shall be installed as work of Division 07. Mount ventilator securely to roof curb in accordance with manufacturer's instructions and recognized industry standards.
 2. Install in accordance with manufacturer's instructions and recommendations.
 3. Comply with installation provisions of installer of existing roofing system to maintain existing system warranty.
 4. Anchor units securely to supporting structural substrates, adequate to withstand lateral and thermal stresses and inward and outward loading pressures.
 5. Except as otherwise indicated, install roof accessory items in accordance with construction details of "NRCA Roofing and Waterproofing Manual".
 6. Where metal surfaces of units to be installed come in contact with non-compatible metal or corrosive substrates, including wood, apply bituminous coating on concealed metal surfaces, or provide other permanent separation.
- 3.04 IDENTIFICATION
 - A. Provide equipment identification for all ventilators.
- 3.05 FIELD QUALITY CONTROL
 - A. Upon completion of installation, start-up and test each power and gravity ventilator to demonstrate capabilities and compliance with requirements.
 - B. Where possible, field correct malfunctioning units then retest to demonstrate compliance.
 - C. Replace units which cannot be satisfactorily corrected.
- 3.06 ADJUSTMENT AND CLEANING
 - A. Clean factory-finished surfaces. Repair marred or scratched surfaces with Manufacturer's touch- up paint.

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 – GENERAL

- 1.01 DESCRIPTION OF WORK
 - A. Extent of outlets and inlets work is indicated by drawings and schedules, and by requirements of this Section.
 - B. Types of outlets and inlets required for project include the following:
 1. Wall registers and grilles.
- 1.02 QUALITY ASSURANCE
 - A. ASHRAE Standards - Comply with American Society of Heating, Refrigerating, and Air- Conditioning Engineers, Inc. (ASHRAE) Standard 70 "Methods Of Testing For Rating The Air Flow Performance Of Outlets and Inlets".

- B. ADC Test Code - Comply with Air Diffusion Council (ADC) Equipment Test Code 1062R4 "Certification, Rating and Test Manual".
- C. AMCA Standards - Comply with Air Movement and Control Association, Inc. (AMCA) Standard 500 "Test Method For Louvers, Dampers and Shutters".
- D. ANSI/NFPA Standards - Comply with National Fire Protection Association (NFPA) Standard 90A "Installation of Air Conditioning and Ventilating Systems".
- E. ARI Standard - Comply with Air Conditioning and Refrigeration Institute (ARI) Standard 650 - "Air Outlets and Inlets".

1.03 SUBMITTALS

- A. Product Data - Submit manufacturer's data on outlets and inlets including the following:
 - 1. Schedule of outlets and inlets indicating drawing designation, model number, size, and accessories furnished.
 - 2. Data sheet for each type of outlet and inlet, and accessory furnished; indicating construction, finish, and mounting details.
 - 3. Performance data for each type of outlet and inlet furnished, including pressure drop, throw and drop, and noise criteria ratings. Indicate selections on data.
- B. Maintenance Data - Submit maintenance instructions, including cleaning instructions for finishes, and spare parts lists. Include this data in maintenance manuals.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Deliver outlets and inlets wrapped in factory-fabricated fiberboard type containers. Identify on outside of container type of outlet or inlet and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in devices.
- B. Store outlets and inlets in original cartons and protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

PART 2 – PRODUCTS

2.01 GRILLES

- A. Manufacturers:
 - 1. Titus.
 - 2. Carnes.
 - 3. A-J Manufacturing Company.
 - 4. Or equal.
- B. Construction: Provide grilles constructed of aluminum or stainless steel as scheduled.
- C. Performance: Provide grilles that do not exceed scheduled maximum pressure drop and noise criteria ratings at scheduled airflow rate or airflow rate as shown on drawings.
- D. Substrate Compatibility: Provide grilles with border styles that are compatible with adjacent substrate and specifically manufactured to fit into construction openings with accurate fit and adequate support. Refer to Drawings and Specifications for types of substrate which will contain each type of grille.
- E. Grille Face / Pattern: Provide grilles of the following face / pattern type as scheduled. Blade width and spacing shall be dictated by the model number shown in the schedules.
 - 1. Single Deflection: Provide grilles with 3/4-inch horizontal or vertical set of blades. Refer to schedules for position of each set of blades.
- F. Finish: Provide grilles with anodized, matte, or white baked enamel finish as scheduled.

PART 3 – EXECUTION

- 3.01 INSPECTION
 - A. Examine areas and conditions under which outlets and inlets are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.
- 3.02 INSTALLATION
 - A. Install outlets and inlets in accordance with manufacturer's written instructions.
 - B. Check location of outlets and inlets and make necessary adjustments in position to conform to architectural features, symmetry, and lighting arrangement.
 - C. Install diffusers to ductwork with airtight connection.
 - D. Provide balancing dampers on all individual duct take-off to each diffuser and grille whether depicted on Plans or not. All manual volume dampers shall meet the requirements of Section 23 33 00.
 - E. Paint ductwork visible behind air outlets and inlets matte black.
- 3.03 SPARE PARTS
 - A. Furnish to Owner, with receipt, operating keys for each type of outlet and inlet that requires them.

ELECTRICAL HEATING TERMINALS

PART 1 – GENERAL

- 1.01 SUMMARY
 - A. This section identifies electric heating terminals and all associated controls and accessories to be furnished and installed as shown on HVAC drawings and schedules and as specified herein. Electric heating terminals required for this project include:
 - 1. Propeller Electric Unit Heaters.
 - B. The following is not work of this section, refer to Division 26.
 - 1. Power supply wiring from power source to power connection on electric heaters. All components required to make a complete installation shall be provided, including but not limited to starters, disconnects and required electrical devices. Electrical equipment specified to be furnished or factory installed by manufacturer shall be provided under this section.
 - C. Control and interlock wiring between electric heaters and field installed devices is work of this section. All wiring shall be installed in accordance with Division 26.
- 1.02 SUBMITTALS
 - A. Product Data - Submit manufacturer's technical data for electric heating terminals. Include in submittal, specifications, capacity ratings, dimensions, weights, materials, accessories furnished, and installation instructions.
 - B. Shop Drawings - Submit assembly-type shop drawings showing unit dimensions, construction details, methods of assembly of components, and field connection details.
 - C. Controls - Submit manufacturers technical data for all factory wired control devices.
 - D. Wiring Diagrams - Submit manufacturer's electrical requirements for power supply wiring to equipment. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
 - E. Operation and Maintenance Data - Submit operation and maintenance data and parts list for piece of scheduled equipment, accessory, and control. Include this data and product data in manual in accordance with requirements of Section 01 78 23.
- 1.03 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: electric heating terminals from firms regularly engaged in manufacture of same types and sizes of equipment required, whose products have been in satisfactory use in similar service for not less than 3 years.
- B. Regulatory Requirements:
 - 1. NFPA Compliance - Comply with applicable requirements of NFPA pertaining to installation of space heating equipment. Comply with applicable requirements of NFPA N. 90A pertaining to installation of ac systems.
 - 2. UL Compliance - Provide electric heating terminals which are designed, manufactured, and tested in accordance with UL 1042. Provide heating terminals that are UL listed and labeled.
 - 3. SMACNA - Comply with applicable parts of SMACNA's "Ducted Electric Heat Guide for Air Handling Systems".

PART 2 – PRODUCTS

2.01 PROPELLER ELECTRIC UNIT HEATERS

- A. Manufacturers:
 - 1. Qmark.
 - 2. Berko.
 - 3. Or equal.
- B. Type: Propeller type electric unit heater.
- C. Construction: Unit casing shall be constructed heavy gauge steel. Provide with louvered air outlet and inlet grille to act as fan guard.
- D. Heating Element: Element shall aluminum-finned, copper clad steel sheath construction. Provide units of voltages and capacities as scheduled.
- E. Fans: Fan shall be of aluminum construction and dynamically balanced. Provide with motors in accordance with Division 26.
- F. Controls: Provide the following control devices prewired to unit.
 - 1. Power contactor.
 - 2. Fan Delay Relay: Provide fan delay relay to keep unit fan running until all heat is dissipated from the heating elements.
 - 3. Automatic overtemperature cutout.
 - 4. Transformer for 24-volt control circuit.
 - 5. Unit mounted thermostat.
- G. Accessories: Provide unit heaters with the following accessories as scheduled:
 - 1. Factory wired disconnect switch.

PART 3 – EXECUTION

3.01 EXAMINATION

- A. Examine areas and conditions under which equipment is to be installed. Do not proceed with installation until unsatisfactory conditions are corrected.

3.02 GENERAL

- A. Install all equipment in accordance with manufacturer's installation instructions, industry standards, local mechanical code and as indicated in this section and on the Drawings.
- B. Coordinate equipment installation locations with other disciplines to avoid conflicts.
- C. Coordinate installation with electrical work for power wiring to each piece of powered equipment.

3.03 INSTALLATION

- A. Electric Heaters:
 - 1. Install in accordance with manufacturer's installation instructions.

2. Install electric unit heaters in accordance with applicable installation requirements of NEC and NECA's "Standard of Installation".
3. Where practical, install unit heaters using manufacturer's standard mounting bracket. Where required, suspend unit heater from substrates by means of threaded rods and building attachments. Adjust hangers so unit is plumb and level. Mount unit heaters at scheduled or noted heights.
4. Where recessed heaters to be installed, coordinate wall penetration requirements.
5. Touch up scratched or marred enclosure surfaces to match original finishes.
6. Clean dust and debris from unit heaters as installed to ensure cleanliness.

3.04 FIELD QUALITY CONTROL

- A. Upon completion of installation, start-up and test each electric heating terminal and control devices to demonstrate capabilities and compliance with requirements.
- B. Where possible, field correct malfunctioning units then retest to demonstrate compliance.

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 – GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Building wires and cables and associated splices, connectors, and terminations for wiring systems rated 600 volts and less.

1.02 DEFINITIONS

- A. Underfloor Conduits.
 - 1. Conduits run underground within perimeter of building walls under building floor. This may consist of 1 conduit, or several conduits grouped together.
- B. Duct Bank Conduits
 - 1. Conduits run underground outside perimeter of building walls. This may consist of 1 conduit, or several conduits grouped together.
- C. Underground Conduits
 - 1. Underground conduits are both underfloor conduits and duct bank conduits.

1.03 SUBMITTALS

- A. Conductor testing results.
- B. Submittals are not required if Contractor supplies materials or equipment as specified. If Contractor proposes substitutions to material or equipment submittals identified below are required.
 - 1. Product data.

1.04 QUALITY ASSURANCE

- A. Items provided under this Section shall be listed or labeled by Underwriters Laboratories, Inc. (UL) or other Nationally Recognized Testing Laboratory (NRTL).
 - 1. Term "NRTL" shall be as defined in Occupational Safety and Health Administration (OSHA) Regulation 1910.7.
 - 2. Terms "listed" and "labeled" shall be as defined in National Electrical Code, Article 100.
- B. Regulatory Requirements:
 - 1. National Electrical Code (NEC): Components and installation shall comply with National Fire Protection Association (NFPA) 70.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver wire and cable according to National Electrical Manufacturers Association (NEMA) WC 26.

PART 2 – PRODUCTS

2.01 BUILDING WIRES AND CABLES

- A. UL-listed building wires and cables with conductor material, insulation type, cable construction, and rating as required to meet application and NEC requirements.
- B. Wire and cable for 600 volts and below: Soft drawn, copper wire with 600 volt insulation.
 - 1. Conductors:
 - a. Stranding: Class B in accordance with ASTM B8.
 - 2. Insulations and Coverings:
 - a. Conform to NEMA WC 70
- C. 480V feeders, branch circuits, service conductors, motor conductors, and duct bank conduits: Single conductor Type XHHW-2.
- D. Panel Board Branch Circuits 240V and Below:

1. Single Conductor Type THHN/THWN (90 degrees Celsius): Above ground and underfloor conduits.
2. Single Conductor Type XHHW-2: Duct bank conduit.
3. 12 American Wire Gauge (AWG) minimum size (unless otherwise noted) for branch circuit wiring, including motor circuits.
4. Size 120 volt branch circuits for length of run on following basis.
 - a. 0 to 50 feet Run From Panelboard to first outlet: 12 AWG minimum.
 - b. 51 to 100 feet Run: Increase one wire size, i.e., 12 AWG becomes 10 AWG.
 - c. 101 to 150 feet Run: Increase two wire sizes, i.e., 12 AWG becomes 8 AWG.
 - d. 151 feet and above: Wiring sized for 3% maximum voltage drop.
5. For other branch circuits, voltage drop for branch circuits and feeder circuit combined shall not exceed requirements of the NEC 215.
- E. Control Circuits:
 1. Single Conductor Type THHN/THWN (90 degrees Celsius): Above ground and underfloor conduits.
 2. 12 AWG minimum size (unless otherwise noted).
- F. Non-shielded Instrumentation, Graphic Indication, and Other Control Wiring Operating at Less Than 120 volt: 14 AWG except as otherwise indicated with same insulation as control circuits.
 1. Single conductor Type THHW/THWN (90 degrees Celsius), above ground and underfloor conduits.
- G. Shielded instrumentation and Resistance Temperature Detector (RTD) wiring, above ground and underfloor conduits:
 1. Polyvinyl Chloride (PVC) insulation, tinned copper (19 by 29) stranded, 16 AWG, twisted pair or triplet cabled with aluminum mylar shielding, stranded, tinned, 18 AWG copper drain wire, and overall black FR-PVC, 90 degrees C, 600 volt jacket.
 2. Multi-wire cable assembly: duct bank conduits.
- H. Multi-Wire Control and Instrumentation Cable Assemblies:
 1. Multi-conductor, color-coded cable with number and size of conductors indicated.
 2. Where spare conductors are not indicated provide 10% spare conductors. One pair minimum.
 3. Control and non-shielded instrumentation.
 - a. Class B stranded in accordance with ASTM B8.
 - b. Type XLPE insulation also meeting requirements of NEMA WC-57.
 - c. Color coded in accordance with ICEA Method 1, Table E-2.
 - d. Cabled with suitable fillers.
 - e. Overall black FR-PVC, 90 degrees Celsius, 600 volt sunlight resistant jacket.
 - f. UL listed for installation in cable trays in accordance with NEC Art. 336, Class I, Division 2 hazardous areas and in accordance with NEC 340 and for direct burial.
 4. Shielded Instrumentation:
 - a. Class B stranded copper in accordance with ASTM B8.
 - b. PVC with nylon armor insulation.
 - c. Twisted pairs color coded in accordance with ICEA Method 1, Table E-2, and numbered.
 - d. Individual and overall aluminum mylar shields and seven strand tinned copper drain wires.
 - e. Overall black FR-PVC 90 degrees C 600 volt sunlight resistant jacket.
 - f. UL listed for installation in cable trays in accordance with NEC 336, Class I, Division 2 hazardous areas, and in accordance with NEC 340 and for direct burial.

2.02 CONNECTORS AND SPLICES

- A. UL-listed factory-fabricated wiring connectors of size, ampacity rating, material, and type and class for application and for service indicated.
- B. Select to comply with Project's installation requirements and as required to meet application.
- C. Conductors 10 AWG and Smaller: 3M Electric Products, Skotchlok, or equal pre insulated spring connector. Comply with manufacturer's packaging requirements for number, size, and combination of conductors.
- D. Conductors 8 AWG and Larger: Bronze 2-bolt type connectors with spacer.
- E. Splices: Burndy Or Equal.

2.03 TERMINATIONS

- A. Power Conductors: Compression crimp type or mechanical lugs.
- B. Control and Instrumentation Conductors: Compression crimp type fork tongue, insulated support type lugs on terminal strips. Do not splice.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Install wires and cables as indicated, according to manufacturer's written instructions and National Electrical Contractors Association (NECA) "Standard of Installation".
- B. Run wire and cable in conduit unless otherwise indicated on Drawings. Pull conductors into raceway simultaneously where more than 1 is being installed in same raceway.
 - 1. Use pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation.
 - 2. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.
 - 3. Do not draw conductor into conduits until building is enclosed, watertight, and work causing cable damage has been completed.
- C. Install cable supports for vertical feeders in accordance with NEC. Provide split wedge type which firmly clamps each individual cable and tightens due to cable weight.
- D. For panelboards, cabinets, wireways, switches, and equipment assemblies, neatly form, train, and tie cables in individual circuits.
- E. Seal cable and wire entering building from underground between wire and conduit, where cable exits conduit, with non-hardening approved compound.
- F. Install wire and cables in separate raceway systems as follows:
 - 1. Exit lights.
 - 2. ac Control.
 - 3. dc control.
 - 4. Shielded instrumentation.
 - 5. Network Cables.
 - 6. Fiber Optic Cables.
 - 7. Intrinsically Safe.
 - 8. Emergency system
 - 9. As required by NEC.
- G. Do not run instrumentation cables into control cabinets or Motor Control Center (MCC) unless cables are terminated in cabinet or MCC.
- H. Wiring at Outlets: Install with at least 12 inch (300 millimeter) of slack conductor at each outlet.
- I. Connect outlets and components to wiring and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts,

according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening torques specified in UL 486A.

- J. Drawings do not designate number of conductors in conduit nor does location of branch circuits and switch legs indicated on Drawings designate location or routing. Route branch circuits and switch legs as dictated by construction and these Specifications.

3.02 TERMINATIONS AND SPLICES

- A. Terminate control, instrumentation, and communication cables on terminal strips in separate terminal cabinets located near conduit entrances of buildings or as shown on Drawings.
- B. Power Cable Splices (no splices in cables unless approved by Engineer):
 - 1. Provide continuous lengths of cable without splices in motor circuits and feeders unless otherwise noted. Splices may be installed in motor circuits and feeders with prior approval by Engineer.
 - 2. Install splices and taps that possess equivalent or better mechanical strength and insulation ratings than conductors being spliced.
 - 3. Use splice and tap connectors that are compatible with conductor material.
 - 4. Where pre-insulated spring connectors are used for equipment connections, tape connector to wire to prevent loosening under vibration.
 - 5. Each tap, joint or splice in conductors 8 AWG and larger shall be taped with two half-lap layers of vinyl plastic electrical tape and finish wrap of color coding tape where required by code.
 - 6. Cable splices shall be made only in manholes, handholes, wireways, distribution boxes, and junction boxes.
- C. Power Cable Terminations:
 - 1. Termination of wires with full compression type or mechanical lugs installed with appropriate hand or hydraulic tool. Use proper dies to achieve the desired compression.
 - 2. For screw type terminal blocks, terminations for stranded conductors shall be made with T & B lock-on fork connector with insulated sleeves.
 - 3. Motor lead conductor terminations shall be made with a T & B or approved equal, full compression lug, full ring type, bolted, and taped as required. For connecting motor lead to service wiring fasten full ring lugs together with cadmium plated steel cap screws, and cover with a minimum of 2 layers 1/2 lap, 3M Scotch No. 33 tape; option: T & B "Motor Stub Splice Insulator".

3.03 CONTROL CIRCUITS

- A. Control circuit home runs from same area for the same system returning to same panel, (e.g., Local Controls Panel (LCP), Control Station (CS), etc.,) may be combined provided signal and voltage types are not mixed.
- B. Following types of home runs shall not be combined with other types:
 - 1. 4-20 milliamp direct current analog; Type 2 shielded cable.
 - 2. 24 volts direct current discrete (e.g., field or LCP powered dry contacts).

3.04 BRANCH CIRCUITS

- A. Motor branch circuits and branch circuits for 3 phase circuits shall not be combined.
- B. Branch circuits for single phase equipment devices from same Lighting Panel (LP) or Power Panel (PP) may be combined provided that such combining does not result in having to derate ampacity of conductors.

3.05 FEEDERS:

- A. Extend feeders at full capacity from origin to termination.

- B. Each conduit raceway shall contain only those conductors constituting single feeder circuit unless otherwise indicated.
- C. Where multiple raceways are used for single feeder, each raceway shall contain conductor of each phase and neutral if used.
- D. Where feeder conductors are run in parallel, conductors shall be of same length, material, circular-mil area, insulation type, and terminated in same manner.
- E. Where parallel feeder conductors run in separate raceways, raceways shall have same physical characteristics.
- F. Confine feeders to insulated portions of building unless otherwise shown.
- G. On network systems, neutral shall be run with phase wires. Unbalanced neutral current shall not exceed normal or derated conductor capacity.

3.06 **MOTORS AND EQUIPMENT WIRING**

- A. Provide motor circuits in accordance with diagrams and schedules on Drawings and code requirements, from source of supply to associated motor starter and starter to motor terminal box, including necessary and required intermediate connections.
- B. Do not include associated control conductors in same conduit with power conductors, unless otherwise indicated.
- C. Provide branch circuits to conform with NEC requirements and nameplate ratings. Contractor responsible for verification of ratings of motors and installing proper branch circuits.

3.07 **COLOR CODING**

- A. Conductors for Lighting and Power Wiring:

Phase	208/120 volts	480/277 volts
A	Black	Brown
B	Red	Orange
C	Blue	Yellow
Travelers	Pink	Purple
Neutral	White	White with non-green stripe
Ground	Green	Green

- A. Colored pressure-sensitive plastic tape.
 - 1. Apply in half overlapping turns for minimum of three inches at terminal points, and in junction boxes, pull boxes, troughs, manholes, and handholes.
 - 2. 3/4 inch wide with colors as specified.
 - 3. Apply last two laps of tape with no tension to prevent possible unwinding.
 - 4. Where cable markings are covered by tape, apply tags to cable stating size and insulation type.
- B. For modifications and additions to existing wiring systems, color coding shall conform to existing wiring system.
- C. Color code for insulated power system wiring shall be in accordance with NEC.
- D. Color code for intrinsically safe systems shall be light blue.

3.02 **CONTROL, COMMUNICATION AND SIGNAL SYSTEM IDENTIFICATION**

- A. Install permanent wire marker at termination.
- B. Identifying numbers and letters on wire markers shall correspond to those on terminal blocks or wiring diagrams used for installing systems.
- B. Plastic sleeve or self adhesive vinyl cloth.

3.08 **FEEDER IDENTIFICATION**

- A. Manholes, handholes, pullboxes, and junction boxes, install metal tags on circuit cables and wires to clearly designate circuit identification and voltage.
- B. Provide tags of embossed brass type, in manholes and handholes showing cable type and voltage rating. Attach tags to cables with slip-free plastic cable lacing units.

3.10 DIRECT BURIAL

- A. Direct bury cables only when indicated on Drawings.
- B. Trench and backfill in accordance with Section 800.
- C. Top of cable shall be minimum 24 inch below final grade with 3-inch sand fill above and below cables.
- D. Roads and Paving:
 - 1. Where direct burial cable crosses under roads or paving, install cable in galvanized steel conduit sleeves a minimum of 30 inch below surface.
 - 2. If paving is in-place when cable is to be installed, wrought iron pipe or galvanized steel conduit may be driven under paving.
 - 3. Extend conduit or pipe 1 foot beyond each side of paving unless otherwise shown on Drawings.
- E. Provide horizontal slack in cables for contraction during cold weather.
- F. Install cable in continuous lengths without splices, unless otherwise shown on Drawings.
- G. Submersible type connections and terminations designed for cables being installed, when indicated.
- H. Install underground line marking tape along and above buried cable in accordance with Section 800.
 - 1. Bury 1 foot below surface before final backfilling.

3.11 FIELD QUALITY CONTROL

- A. Visual and Mechanical Inspection:
 - 1. Inspect cables for physical damage and proper connection in accordance with single-line diagram.
 - 2. Test cable mechanical connections to manufacturer's recommended values using calibrated torque wrench.
 - 3. Check cable color coding with specifications and NEC standards.
- B. Electrical Tests:
 - 1. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 1000 volts direct current for 1 minute.
 - 2. Perform continuity test to insure proper cable connection.
 - 3. Perform tests on the following conductors:
 - a. Incoming service conductors.
 - b. Power transformer conductors.
 - c. Generator feeder conductors.
 - d. Switchboard main and feeder conductors.
 - e. Motor feeders 30HP and greater
- C. Test Values:
 - 1. Evaluation results by comparison with cables of same length and type. Investigate any value less than 50 megohms.
 - 2. Submit reports summarizing the results of the testing.

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.01 SUMMARY

A. Section Includes:

1. Grounding of electrical systems and equipment and basic requirements for grounding for protection of life, equipment, circuits, and systems.
2. Grounding requirements specified in this Section may be supplemented in other Sections of these Specifications.

1.02 SUBMITTALS

A. Report of Field Tests and Observations: Certified by Contractor.

B. Test Results:

1. Certified field tests and observation reports indicating and interpreting test reports for compliance with performance requirements.

1.03 QUALITY ASSURANCE

A. Comply with Underwriters Laboratories, Inc (UL) 467.

B. Items provided under this section shall be listed or labeled by UL or other Nationally Recognized Testing Laboratory (NRTL).

1. Term "NRTL" shall be as defined in Occupational Safety and Health Administration (OSHA) Regulation 1910.7.
2. Terms "listed" and "labeled" shall be as defined in National Electrical Code (NEC), Article 100.

C. Regulatory Requirements:

1. NEC: Components and installation shall comply with National Fire Protection Association (NFPA) 70.

PART 2 – PRODUCTS

2.01 GROUNDING AND BONDING PRODUCTS

A. Governing Requirements: Where types, sizes, ratings, and quantities indicated are in excess of NEC requirements, more stringent requirements and greater size, rating, and quantity indications govern.

2.02 WIRE AND CABLE GROUNDING CONDUCTORS

A. Conform to NEC Table 8, except as otherwise indicated, for conductor properties, including stranding.

1. Material: Copper.

B. Equipment Grounding Conductors: Insulated with green color insulation.

C. Grounding-Electrode Conductors: Stranded cable.

D. Underground Conductors: Bare, tinned, stranded, except as otherwise indicated.

E. Bare Copper Conductors:

1. Solid Conductors: American Society for Testing and Materials (ASTM) B3.
2. Assembly of Stranded Conductors: ASTM B8.
3. Tinned Conductors: ASTM B33.

2.03 MISCELLANEOUS CONDUCTORS

A. Grounding Bus: Bare, annealed-copper bars of rectangular cross section.

B. Braided Bonding Jumpers: Copper tape, braided No. 3/0 American Wire Gauge (AWG) bare copper wire, terminated with copper ferrules.

C. Bonding Straps: Soft copper, 0.05 inch (1 millimeter) thick and 2 inches (50 millimeters) wide, except as indicated.

2.04 CONNECTOR PRODUCTS

- A. Pressure Connectors: High-conductivity-plated units.
- B. Bolted Clamps: Heavy-duty type.
- C. Exothermic-Welded Connections: Provided in kit form and selected per manufacturer's written instructions for specific types, sizes, and combinations of conductors and connected items.

2.05 GROUNDING ELECTRODES AND TEST WELLS

- A. Grounding Rods: Copper-clad steel.
 - 1. Size: 3/4 inch by 120 inches (19 by 3000 millimeters).
- B. Test Wells: Fabricate from 30 inch long, square-cut section of 12-inch diameter, Schedule 80, Polyvinyl Chloride (PVC) pipe with end bell and cast iron cover as detailed on Drawings. Harger 362PS30CILS80 or approved equal.

PART 3 – EXECUTION

3.01 APPLICATION

- A. Equipment Grounding Conductors: Comply with NEC Article 250 for types, sizes, and quantities of equipment grounding conductors, except where specific types, larger sizes, or more conductors than required by NEC are indicated.
 - 1. Install equipment grounding conductor with circuit conductors for items below in addition to those required by Code:
 - a. Feeders and branch circuits.
 - b. Lighting circuits.
 - c. Receptacle circuits.
 - d. Single-phase motor or appliance branch circuits.
 - e. Three-phase motor or appliance branch circuits.
 - f. Flexible raceway runs.
 - 2. Isolated Grounding-Receptacle Circuits: Install separate insulated equipment grounding conductor connected to receptacle grounding terminal. Isolate grounding conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding-conductor terminal of applicable derived system or service, except as otherwise indicated.
 - 3. Isolated Equipment Enclosure Circuits: For designated equipment supplied by branch circuit or feeder, isolate equipment enclosure from supply raceway with nonmetallic raceway fitting listed for purpose. Install fitting where raceway enters enclosure and install separate equipment grounding conductor. Isolate equipment grounding conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding-conductor terminal of applicable derived system or service, except as otherwise indicated.
 - 4. Air-Duct Equipment Circuits: Install equipment grounding conductor to duct-mounted electrical devices operating at 120 volts and above, including air cleaners and heaters. Bond conductor to each unit and to air duct.
- B. Common Ground Bonding with Lightning Protection System: Bond electric power system ground directly to lightning protection system grounding conductor at closest point to electric service grounding electrode. Use bonding conductor sized same as system grounding conductor and install in conduit.
- C. Piping Systems and Other Equipment: Comply with NEC Article 250 for bonding requirements.

3.02 INSTALLATION

- A. Ground electrical systems and equipment according to NEC requirements, except where Drawings or Specifications exceed NEC requirements.
- B. Grounding Rods: Locate minimum of 1 rod length from each other and at least same distance from any other grounding electrode.

1. Drive until tops are 6 inches below finished floor or final grade, except as otherwise indicated.
2. Interconnect with grounding-electrode conductors. Use exothermic welds, except at test wells and as otherwise indicated. Make these connections without damaging copper coating or exposing steel.
- C. Grounding Conductors: Route along shortest and straightest paths possible, except as otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- D. Underground Grounding Conductors: Use bare tinned copper wire. Bury at least 24 inches (600 millimeters) below grade.
- E. Bond interior metal piping systems and metal air ducts to equipment grounding conductors of associated pumps, fans, blowers, electric heaters, and air cleaners. Use braided-type bonding straps.
- F. Test Wells: One for each driven grounding electrode system, except as otherwise indicated. Set top of well flush with finished grade or floor.
- G. Concrete-Encased Grounding Electrode (grounding building/structure footing): Fabricate according to NEC Article 250 using minimum of 20 feet (6 meters) of bare tinned copper conductor not smaller than No. 4 AWG or minimum 20 feet (6 meters) rebar 1/2 inch or larger in diameter. Bond grounding conductor to reinforcing steel to at least 4 locations, and to anchor bolts. Extend grounding conductor up in foundation wall.

3.03 CONNECTIONS

- A. Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
 1. Use electroplated or hot-tin-coated materials to assure high conductivity and to make contact points closer in order of galvanic series.
 2. Make connections with clean, bare metal at points of contact.
 3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
 4. Make aluminum-to-galvanized steel connections with tin-plated copper jumpers and mechanical clamps.
 5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
- B. Exothermic-Welded Connections: Use for connections to structural steel and for underground connections, except those at test wells. Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.
- C. Equipment Grounding-Wire Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.
- D. Noncontact Metal Raceway Terminations: Where metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with bare grounding conductor to grounding bus or terminal in housing. Bond electrically noncontinuous conduits at both entrances and exits with grounding bushings and bare grounding conductors, except as otherwise indicated.
- E. Connections at Test Wells: Use compression-type connectors on conductors and make bolted- and clamped-type connections between conductors and grounding rods.

- F. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. Where these requirements are not available, use those specified in UL 486A and UL 486B.
- G. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by manufacturer of connectors. Provide embossing die code or other standard method to make visible indication that connector has been adequately compressed on grounding conductor.
- H. Moisture Protection: Where insulated grounding conductors are connected to grounding rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.04 FIELD QUALITY CONTROL

A. Testing:

- 1. Subject completed grounding system to megger test at each location where maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells.
 - a. Measure ground resistance not less than 2 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. Perform tests by 2 point method according to Section 9.03 of Institute of Electrical And Electronics Engineers (IEEE) 81.
- 2. Maximum grounding to resistance values are as follows:
 - a. Equipment Rated 500 kilovolt amps (kVA) and Less: 10 ohms.
 - b. Equipment Rated 500 to 1000 kVA: 5 ohms.
 - c. Equipment Rated More than 1000 kVA: 3 ohms.
 - d. Unfenced Substations and Pad-Mounted Equipment: 5 ohms.
 - e. Manhole Grounds: 10 ohms.
- 3. Excessive Ground Resistance: Where resistance to ground exceeds specified values, notify ENGINEER promptly and include recommendations to reduce ground resistance and to accomplish recommended work.
- 4. Report: Prepare certified test reports, of ground resistance at each test location. Include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

3.05 RESTORATION

- A. Restore surface features, including vegetation, at areas disturbed by work of this Section.
 - 1. Re-establish original grades, except as otherwise indicated.
 - 2. Where sod has been removed, replace it as soon as possible after backfilling is completed.
 - 3. Restore areas disturbed by trenching, storing of dirt, cable laying, and other activities to their original condition.
 - 4. Include topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching.
 - 5. Maintain restored surfaces.
 - 6. Restore disturbed paving.

HANGERS AND SUPPORTING FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.01 SUMMARY

A. Section Includes:

1. Supports from building structure for electrical items by means of hangers, supports, anchors, sleeves, inserts, seals, and associated fastenings.

1.02 QUALITY ASSURANCE

A. Items provided under this section shall be listed and labeled by Underwriters Laboratories, Inc. (UL) or other Nationally Recognized Testing laboratory (NRTL).

1. Term "NRTL" shall be as defined in Occupational Safety and Health Administration (OSHA) Regulation 1910.7.
2. Terms "listed" and "labeled" shall be as defined in National Electrical Code (NEC), Article 100.

B. Regulatory requirements:

1. NEC: Components and installation shall comply with National Fire Protection Association (NFPA) 70.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Refer to Space Environment and Hazardous Ratings Schedule on Drawings for determination of the Exposure type of each space in which hangers and supports are to be installed. Refer to Material Schedule on Drawings for material type to be utilized within each Exposure type.

B. As otherwise indicated and as required by NEC.

C. Provide dissimilar metal separation where metallic conduit materials differ from metallic hangers and supports materials.

2.02 MANUFACTURED SUPPORTING DEVICES

A. Raceway Supports: Clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps.

B. Fasteners: Types, materials, and construction features as follows:

1. Expansion Anchors: Stainless steel wedge or sleeve type.
2. Toggle Bolts: All stainless steel springhead type.
3. Powder-Driven Threaded Studs: Heat-treated stainless steel, designed specifically for intended service.
4. Nuts, Washers, and Bolts: Stainless steel.

C. Conduit Sealing Bushings: Factory-fabricated watertight conduit sealing bushing assemblies suitable for sealing around conduit passing through concrete floors and walls. Construct seals with steel sleeve, malleable iron body, neoprene sealing grommets or rings, metal pressure rings, pressure clamps, and cap screws.

D. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for nonarmored electrical cables in riser conduits. Provide plugs with number and size of conductor gripping holes as required to suit individual risers.

E. U-Channel Systems: Channels, with 9/16-inch diameter holes, at minimum of 8 inch on center, in top surface. Provide fittings and accessories that mate and match with U-channel and are of same manufacture.

2.03 FABRICATED SUPPORTING DEVICES

- A. Shop- or field-fabricate supports or manufacture supports assembled from U-channel components.
 - B. Brackets: Fabricated of angles, channels, and other standard structural shapes. Connect with welds and machine bolts to form rigid supports.
 - C. Pipe Sleeves: Provide pipe sleeves of one of following:
 - 1. Sheet Metal: Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate sleeves from following gage metal for sleeve diameter noted:
 - a. 3 inch and smaller: 20 gauge.
 - b. 4 inch to 6 inch: 16 gauge.
 - c. Over 6 inch: 14 gauge.
 - 2. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe.
 - 3. Plastic Pipe: Fabricate from Schedule 80 PVC plastic pipe.
- 2.04 FIRE RESISTANT JOINT SEALERS
- A. Manufacturers:
 - 1. "Dow Corning Fire Stop Foam," Dow Corning Corp.
 - 2. "Pensil 851," General Electric Co.
 - 3. Or equal.
 - B. Two-part, foamed-in-place, silicone sealant formulated for use in through-penetration fire-stopping around cables, conduit, pipes, and duct penetrations through fire-rated walls and floors.
 - C. Sealants and accessories shall have fire-resistance ratings indicated, as established by testing identical assemblies in accordance with American Society for Testing and Materials (ASTM) E 814, by Underwriters' Laboratories, Inc., or other testing and inspection agency acceptable to authorities having jurisdiction.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Install supporting devices to fasten electrical components securely and permanently in accordance with NEC requirements.
- B. Coordinate with structural system and with other electrical installation. Coordinate with light fixtures to ensure hangers and supports are not mounted lower or below light fixtures causing shadows.
- C. Raceway Supports: Comply with NEC and following requirements:
 - 1. Conform to manufacturer's recommendations for selection and installation of supports.
 - 2. Strength of each support shall be adequate to carry present and future load multiplied by safety factor of at least four. Where this determination results in safety allowance of less than 200 pounds, provide additional strength until there is minimum of 200 pounds safety allowance in strength of each support.
 - 3. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.
 - 4. Support parallel runs of horizontal raceways together on trapeze-type hangers.
 - 5. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 1 inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings only. For hanger rods with spring steel fasteners, use 1/4 inch diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing.

6. In vertical runs, arrange support so load produced by weight of raceway and enclosed conductors is carried entirely by conduit supports with no weight load on raceway terminals.
- D. Miscellaneous Supports: Support miscellaneous electrical components as required to produce same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.
- E. Sleeves: Install in concrete slabs and walls and other fire-rated floors and walls for raceways and cable installations. For sleeves through fire rated-wall or floor construction, apply UL listed firestopping sealant in gaps between sleeves and enclosed conduits and cables.
- F. Conduit Seals: Install seals for conduit penetrations of slabs below grade and exterior walls below grade and where indicated. Tighten sleeve seal screws until sealing grommets have expanded to form watertight seal.
- G. Conduit extending through roof shall pass through ceiling box at roof line.
 1. Provide 14 gauge minimum copper box complete with watertight soldered seams and flanged to serve as pitch pocket for each conduit.
 2. Install conduit and pitch pocket in advance of roofing work.
- H. Fastening: Unless otherwise indicated, fasten electrical items and their supporting hardware securely to building structure, including but not limited to conduits, raceways, cables, cable trays, busways, cabinets, panelboards, transformers, boxes, disconnect switches, and control components in accordance with following:
 1. Fasten by means of wood screws or screw-type nails on wood, toggle bolts on hollow masonry units, concrete inserts or expansion bolts on concrete or solid masonry, and machine screws, welded threaded studs, or spring-tension clamps on steel. Threaded studs driven by powder charge and provided with lock washers and nuts may be used instead of expansion bolts and machine or wood screws. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures. In partitions of light steel construction, use sheet metal screws.
 2. Holes cut in concrete shall not cut main reinforcing bars. Fill holes that are not used.
 3. Load applied to any fastener shall not exceed 25% of proof test load. Use vibration- and shock- resistant fasteners for attachments to concrete slabs.

CABINETS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.01 SUMMARY

- A. Section Includes:
 1. Outlet and device boxes.
 2. Pull and junction boxes.
 3. Boxes and fittings for hazardous locations.
- B. Conduit-body-type electrical enclosures and wiring fittings are specified in Section 26 05 33.16.

1.02 DEFINITIONS

- A. Cabinets: Enclosure designed either for surface or for flush mounting and having frame, or trim in which door or doors may be mounted.
- B. Device Box: Outlet box designed to house receptacle device or wiring box designed to house switch.

- C. Enclosure: Box, case, cabinet, or housing for electrical wiring or components.
 - D. Hinged Door Enclosure: Enclosure designed for surface mounting and having swinging doors or covers secured directly to and telescoping with walls of box.
 - E. Outlet Box: Wiring enclosure where current is taken from wiring system to supply utilization equipment.
 - F. Wiring Box: Enclosure designed to provide access to wiring systems or for mounting of indicating devices or of switches for controlling electrical circuits.
- 1.03 SUBMITTALS
- A. Product Data: Submit for cabinets and enclosures with classification higher than National Electrical Manufacturers Association (NEMA) 1.
- 1.04 QUALITY ASSURANCE
- A. Items provided under this section shall be listed or labeled by Underwriters Laboratories, Inc. (UL) or other Nationally Recognized Testing Laboratory (NRTL).
 - 1. Term "NRTL" shall be as defined in Occupational Safety and Health Administration (OSHA) Regulation 1910.7.
 - 2. Terms "listed" and "labeled" shall be as defined in National Electrical Code (NEC), Article 100.
 - B. Regulatory Requirements:
 - 1. NEC: Components and installation shall comply with National Fire Protection Association (NFPA 70).

PART 2 – PRODUCTS

- 2.01 CABINETS, BOXES, AND FITTINGS, GENERAL
- A. Electrical Cabinets, Boxes, and Fittings: Of indicated types, sizes, and NEMA enclosure classes. Where not indicated, provide units of types, sizes, and classes appropriate for use and location. Provide items complete with covers and accessories required for intended use. Provide gaskets for units in damp or wet locations.
- 2.02 MISCELLANEOUS MATERIALS AND FINISHES
- A. Fasteners for General Use: Corrosion resistant screws and hardware including cadmium and zinc plated items.
 - B. Fasteners for Exterior or Wet Locations: Stainless steel screws and hardware.
 - C. Fittings for Boxes, Cabinets, and Enclosures: Conform to UL 514B. Malleable iron or zinc plated steel for conduit hubs, bushings and box connectors.
 - D. Finishes:
 - 1. Exterior Finish: Galvanized or Gray baked enamel for items exposed in finished locations except as otherwise indicated.
 - 2. Interior Finish: Where indicated, white baked enamel.
 - E. Fastener style:
 - 1. Stainless steel door clamp assembly (Hoffman SSLP (SS6LP for 316 SS) series, Wiegmann SSN4 series or equal) for stainless steel boxes. Screw-down clamps are not acceptable.
 - 2. Snap-hinge covers or quarter turn semi-flush oil tight latch for non-metallic boxes.
 - 3. External quick-release or quarter turn semi-flush oil tight latch latches for galvanized boxes.
 - 4. Spring loaded, stainless steel, triple-thread, captive hex-head bolts for cast metal boxes.
- 2.03 METAL OUTLET, DEVICE, AND SMALL WIRING BOXES
- A. General:
 - 1. Conform to UL 514A and UL 514B.
 - 2. Boxes shall be of type, shape, size, and depth to suit each location and application.

- B. Steel Boxes: Conform to NEMA OS 1. Boxes shall be sheet steel with stamped knockouts, threaded screw holes and accessories suitable for each location including mounting brackets and straps, cable clamps, exterior rings and fixture studs.
 - C. Galvanized Cast-Iron Boxes: Iron alloy, waterproof, with threaded raceway entries and features and accessories suitable for each location, including mounting ears, threaded screw holes for devices and closure plugs.
- 2.04 PULL AND JUNCTION BOXES
- A. General: Comply with UL 50 for boxes over 100 cubic inch volume. Unless otherwise noted, boxes shall have continuous hinge on one side with fastening mechanism on the opposite side. Cover shall be of material same as box and shall be of size and shape to suit application.
 - B. Galvanized Steel Boxes: Flat rolled, code gauge, sheet steel with welded seams. Where necessary to provide rigid assembly, construct with internal structural steel bracing. Hot-dip galvanized after fabrication. Cover shall be gasketed.
 - C. Stainless-Steel Boxes: Fabricate of stainless steel conforming to Type 316 of American Society for Testing and Materials (ASTM) A167. Where necessary to provide rigid assembly, construct with internal structural stainless steel bracing. Cover shall be gasketed.
 - D. Galvanized Cast-Iron Boxes: Molded of cast iron alloy with gasketed cover and integral threaded conduit entrances.
 - E. Boxes Approved for Classified Locations: Cast metal or cast nonmetallic boxes conforming to UL 886 listed and labeled for use in specific location, classification, and with specific hazardous material encountered. Conduit entrances shall be integral threaded type. When located outdoors or in wet locations provide O-ring/gasket or equivalent making box suitable for outdoor use.
- 2.05 TERMINAL STRIPS
- A. Manufacturers:
 - 1. Square D.
 - 2. Buchanan.
 - 3. Or equal.
 - B. Channel mount snap-on type.
 - C. Individual gangable with nylon bases.
 - D. Solderless box lug type rated at 600 volts to accommodate No. 22 to 8 American Wire Gauge (AWG) wire or as otherwise indicated.
 - E. Provide 50% spare terminals.

PART 3 – EXECUTION

- 3.01 INSTALLATION, GENERAL
- A. Locations: Install items where indicated and where required to suit code requirements and installation conditions.
 - B. Cap unused knockout holes where blanks have been removed and plug unused conduit hubs.
 - C. Support and fasten items in accordance with Section 26 05 29.
 - D. Sizes shall be adequate to meet NEC volume requirements, but in no case smaller than sizes indicated.
 - E. Remove sharp edges where they may come in contact with wiring or personnel.
- 3.02 APPLICATIONS
- A. Outlet Boxes and Fittings: Install outlet and device boxes and associated covers and fittings of materials and NEMA types for each location in conformance with following requirements unless otherwise noted:

1. Refer to Space Environment and Hazardous Ratings Schedule on Drawings for determination of the Exposure type of each space in which box is to be installed. Refer to Material Schedule on Drawings for material and NEMA enclosure type to be utilized within each Exposure type.
2. NEMA 7 in Class I hazardous classified locations. When located in exterior locations or in wet locations provide O-ring/gasket or equivalent making box suitable for outdoor use.
3. Metal Door Jambs: Narrow partition boxes with internal ears.
4. As otherwise indicated and as required by NEC.
- B. Pull and Junction Boxes: Install pull and junction boxes of materials and NEMA types for each location in conformance with following requirements unless otherwise noted:
 1. Refer to Space Environment and Hazardous Ratings Schedule on Drawings for determination of the Exposure type of each space in which box is to be installed. Refer to Material Schedule on Drawings for material and NEMA enclosure type to be utilized within each Exposure type.
 2. NEMA 7 in Class I hazardous classified locations. When located in exterior locations or in wet locations provide O-ring/gasket or equivalent making box suitable for outdoor use.
 3. As otherwise indicated and as required by NEC

3.03 INSTALLATION OF OUTLET BOXES

- A. Outlets at Windows and Doors: Locate close to window or door trim.
- B. Column and Pilaster Locations: Locate outlet boxes for switches and receptacles on columns or pilasters so centers of columns are clear for future installation of partitions.
- C. Locations in Special Finish Materials: For outlet boxes for receptacles and switches mounted in desks or furniture cabinets or in glazed tile, concrete block, marble, brick, stone or wood walls, use rectangular shaped boxes with square corners and straight sides. Install boxes without plaster rings. Saw cut recesses for outlet boxes in exposed masonry walls.
- D. Gasketed Boxes: At following locations use cast metal, threaded hub type boxes with gasketed weatherproof covers:
 1. Exterior locations.
 2. Where surface mounted on unfinished walls, columns or pilasters. (Cover gaskets may be omitted in dry locations).
 3. Where exposed to moisture laden atmosphere.
 4. Where indicated.
- E. Mounting: Mount outlet boxes for switches with long axis vertical or as indicated. Mount boxes for receptacles vertically. Gang boxes shall be mounted with long axis horizontal. Locate box covers or device plates so they will not span different types of building finishes either vertically or horizontally. Locate boxes for switches near doors on side opposite hinges and close to door trim, even though electrical floor plans may show them on hinge side.
- F. Ceiling Outlets: For fixtures, where wiring is concealed, use outlet boxes 4 inch sq by 1-1/2 inch deep, minimum with raised plaster or tile cover. Provide 3/8 inch fixture stud.
- G. Cover Plates for Surface Boxes: Use plates sized to box front without overlap.
- H. Protect outlet boxes to prevent entrance of plaster, and debris. Thoroughly clean foreign material from boxes before conductors are installed.
- I. Concrete Boxes: Use extra deep boxes to permit side conduit entrance without interfering with reinforcing, but do not use such boxes with over 6 inch depth.
- J. Secure boxes rigidly to substrate upon which being mounted or solidly embed boxes in concrete or masonry. Do not support from conduit, mechanical ductwork or piping.

- K. Set boxes in concealed conduit runs, flush with wall surfaces, with or without covers as required.
- L. Do not install boxes back to back or through wall. Offset outlet boxes on opposite sides of wall minimum 12 inch
- M. Set outlet boxes parallel to construction, securely mounted and adjusted to set true and flush with finished surface.
- N. Do not burn holes, use knockout punches or saw.
- O. Use handy boxes only where specifically indicated.
- P. Provide outlet box divider barriers between 277/480 volt and 120/240 volt devices as required per NEC.
- Q. Where emergency switches occur adjacent to normal light switches, install in separate boxes in accordance with NEC and device plate color coding separation.
- R. Existing Outlet Boxes: Where extension rings are required to be installed, drill new mounting holes in rings to align with mounting holes on existing boxes where existing holes are not aligned.

3.04 OUTLET BOX LOCATIONS

- A. Locate flush mounted wall boxes in corner of nearest brick or block to keep cutting to minimum.
- B. Location of outlets and equipment as shown on Drawings is approximate and exact location to be verified and shall be determined by:
 - 1. Construction or code requirements.
 - 2. Conflict with equipment or other trades.
 - 3. Equipment manufacturer's drawings.
- C. Minor modification in location of outlets and equipment considered incidental up to distance of 10 feet with no additional compensation, provided necessary instructions given prior to roughing in of outlet.
- D. Mounting heights for devices and equipment to be measured from finished floor to centerline of device and unless otherwise noted on Drawings as follows.
 - 1. Switches: 48 inch above floor.
 - 2. Alternating Current Receptacles: 15 inch above floor or 6 inch above counters, counter backsplashes, and baseboard radiators in finished areas; 48 inch above floor in unfinished areas.
 - 3. Pushbuttons: 48 inch above floor.
 - 4. Motor Starters and Disconnect Switches: 60 inch above floor
 - 5. Thermostats: 60 inch above floor.

3.05 INSTALLATION OF PULL AND JUNCTION BOXES

- A. Box Selection: For boxes in main feeder conduit runs, use sizes not smaller than 8 inch sq by 4 inch deep. Do not exceed 6 entering and 6 leaving raceways in single box. Quantities of conductors (including equipment grounding conductors) in pull or junction box shall not exceed following:

Size of Largest Conductors in Box	Maximum No. of Conductors in Box
No. 4/0 AWG	30
250 Kcmil	20
500 Kcmil	15
Over 500 Kcmil	10

- 1. Cable Supports: Install clamps, grids, or devices to which cables may be secured. Arrange cables so they may be readily identified. Support cable at least every 30 inch inside boxes.
- 2. Mount pull boxes in inaccessible ceilings with covers flush with finished ceiling.

3. Size: Provide pull and junction boxes for telephone, signal, instrumentation, control, and other systems at least 50% larger than would be required by the NEC for boxes smaller than 24 inch by 24 inch, or as indicated. Locate boxes strategically and provide shapes to permit easy pulling of future wires or cables of types normal for such systems.
- 3.06 GROUNDING
 - A. Electrically ground metallic cabinets, boxes, and enclosures. Where wiring to item includes grounding conductor, provide grounding terminal in interior of cabinet, box or enclosure.
- 3.07 CLEANING AND FINISH REPAIR
 - A. Upon completion of installation, inspect components. Remove burrs, dirt, and construction debris and repair damaged finish including chips, scratches, abrasions, and weld marks.
 - B. Galvanized Finish: Repair damage using zinc-rich paint recommended by manufacturer.
 - C. Painted Finish: Repair damage using matching corrosion inhibiting touch-up coating.

CONDUIT FOR ELECTRICAL SYSTEMS

PART 1 – GENERAL

- 1.01 SUMMARY
 - A. Section includes:
 1. Raceways:
 - a. Galvanized rigid steel conduit (GRS).
 - b. Polyvinyl chloride (PVC) externally coated galvanized rigid steel conduit (CGRS).
 - c. Liquidtight flexible metal conduit (LFMC).
 - d. Wireway (WW).
- 1.02 DEFINITIONS
 - A. Underfloor Conduits.
 1. Conduits which run underground within perimeter of building walls under building floor. This may consist of one conduit, or several conduits grouped together.
 - B. Duct Bank Conduits
 1. Conduits which run under ground outside perimeter of building walls. This may consist of one conduit, or several conduits grouped together.
 - C. Underground Conduits
 1. Underground conduits are both underfloor conduits and duct bank conduits.
- 1.03 SUBMITTALS
 - A. Submittals are not required if Contractor supplies materials or equipment as specified. If Contractor proposes substitutions to material or equipment submittals identified below are required.
 1. Product data.
- 1.04 QUALITY ASSURANCE
 - A. Items provided under this section shall be listed or labeled by Underwriters Laboratories, Inc. (UL) or other Nationally Recognized Testing Laboratory (NRTL).
 1. Term "NRTL" shall be as defined in Occupational Safety and Health Administration (OSHA) Regulation 1910.7.
 2. Terms "listed" and "labeled" shall be as defined in National Electrical Code (NEC), Article 100.

- B. Regulatory Requirements:
 - 1. NEC: Components and installation shall comply with National Fire Protection Association (NFPA) 70.
- C. Comply with National Electrical Contractors Association (NECA) "Standard of Installation."

PART 2 – PRODUCTS

2.01 METAL CONDUIT

- A. Galvanized Rigid Steel Conduit: American National Standards Institute (ANSI) C80.1.
- B. Plastic-Coated Steel Conduit and Fittings: National Electrical Manufacturers Association (NEMA) RN 1 and ETL Verified Polyvinyl Chloride-001 Labeled.
- C. Liquidtight Flexible Metal Conduit: Flexible steel conduit with Polyvinyl Chloride (PVC) jacket.

2.02 NONMETALLIC CONDUIT

- A. Rigid Nonmetallic Polyvinyl Chloride (PVC) Conduit: NEMA TC 2, PVC Chloride
 - 1. Concrete Encased: Schedule 40.
 - 2. Direct Buried: Schedule 80.
- B. PVC Conduit Fittings: NEMA TC 3; match to conduit type and material.

2.03 FITTINGS

- A. Fittings and conduit bodies for steel conduits:
 - 1. Steel or malleable iron, zinc galvanized, or cadmium plated.
 - 2. Do not use set screw or indentor type fittings.
 - 3. Do not use aluminum or die cast fittings.
 - 4. GRS Connectors and Couplings:
 - a. Threaded.
 - b. Insulated throat.
 - c. Gland compression type.
 - d. Rain and concrete type.
 - 5. Comply with NEMA FB 1, compatible with conduit materials.
- B. Fittings for liquidtight flexible non-metallic conduit.
 - 1. Insulated throat type.
 - 2. Threaded.
 - 3. Non-metallic nylon type.
 - 4. One piece sealing "O" rings with connectors when entering boxes or enclosures.
 - 5. Hazardous Locations: Stainless steel.
- C. PVC Conduit Fittings:
 - 1. NEMA TC 3; match to conduit type and material.
- D. Expansion Joints:
 - 1. Conduit expansion fittings complete with copper bonding jumper, Crouse-Hinds Type XJ.
 - 2. Conduit expansion/deflection fittings with copper bonding jumper, Crouse-Hinds Type XD.
- E. Seals:
 - 1. Wall entrance, OZ/Gedney Type FSK or FSC.
- F. Drain Fittings:
 - 1. Automatic Drain Breather:
 - a. Explosionproof.
 - 1) Safe for Class I Division 1, Groups C and D.
 - b. Capable of passing minimum 25 cubic centimeters of water per minute and minimum 0.05 cubic feet of air per minute at atmospheric pressure.

- c. When located exterior or in wet locations provide drain suitable for outdoor use.
 - 2. Condensate Drain:
 - a. Conduit outlet body, Type T.
 - b. Threaded, galvanized plug with 3/16 inch drilled holed through plug.
- 2.04 WIREWAYS
 - A. Wireways larger than 18" long by 6" deep by 6" high and used as anything but a below panelboard pull point is not allowed without prior approval by Engineer.
 - B. Material: Sheet metal sized and shaped as indicated.
 - C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireway as required for complete system.
 - D. Select features where not otherwise indicated, as required to complete wiring system and to comply with NEC.
 - E. Wireway Covers:
 - 1. Hinged type for dry locations.
 - 2. Bolted cover with gasket for wet locations.
 - 3. Provide internal, metal partition to separate power and control conductors.
 - F. Finish: Manufacturer's standard enamel finish unless otherwise noted.
- 2.05 RACEWAY/DUCT SEALING COMPOUND
 - A. Nonhardening, putty-like consistency workable at temperatures as low as 35oF.
 - B. Compound shall not slump at temperature of 300 oF and shall readily adhere to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

PART 3 – EXECUTION

3.01 EXAMINATION

- A. Examine surfaces to receive raceways, wireways, and fittings for compliance with installation tolerances and other conditions affecting performance of raceway system.
- B. Coordinate layout and installation of raceway and boxes with other construction elements to ensure adequate headroom, working clearance, and access. Coordinate layout and installation of raceway and boxes with light fixtures to ensure raceway and boxes are not mounted lower or below light fixtures causing shadows.

3.02 WIRING METHODS

- A. Exterior or Wet Locations:
 - 1. Refer to Space Environment and Hazardous Ratings Schedule on Drawings for determination of the Exposure type of each space in which conduit is to be installed. Refer to Material Schedule on Drawings for conduit material to be utilized within each Exposure type.
 - 2. Underground Power, Single Run: Rigid nonmetallic (PVC) conduit.
 - 3. Underground Power, Grouped: Rigid nonmetallic (PVC) conduit.
 - 4. Underground Shielded Instrumentation Cables, Single Run or Grouped: PVC-coated steel conduit.
 - 5. Connection to Vibrating Equipment (including transformers and hydraulic, pneumatic, or electric solenoid or motor-driven equipment): Liquidtight flexible metal conduit.
- B. Indoor Dry Locations:
 - 1. Refer to Space Environment and Hazardous Ratings Schedule on Drawings for determination of the Exposure type of each space in which conduit is to be installed. Refer to Material Schedule on Drawings for conduit material to be utilized within each Exposure type.

2. Connection to Vibrating Equipment (including transformers and hydraulic, pneumatic, or electric solenoid or motor-driven equipment): Liquidtight flexible metal conduit.
- C. Use 3/4 inch minimum size unless otherwise noted except conduit runs to room light switches may be 1/2 inch.
- D. Underground conduits:
 1. PVC-coated steel conduit may be used without encasing in concrete for underfloor shielded instrumentation cables or where specifically indicated on Drawings.
 2. PVC conduit may be used without encasing in concrete for underfloor power and control conduit or where specifically indicated on Drawings.
 3. Underground conduit shall be minimum of 1 inch outside of the building and minimum 3/4 inch within the building, buried at depth of not less than 24 inch below grade.
 4. Provide conduits or ducts terminating below grade with means to prevent entry of dirt and moisture.
 5. When using underfloor PVC conduit, provide either:
 - a. PVC coated galvanized rigid steel elbows.
 - b. RTRC fiberglass elbows with factory installed PVC couplings when connecting to PVC conduit.
 6. Curves and Bends: Use manufactured elbows for stub-ups at equipment and at building entrances. For other curves and bends, except as otherwise indicated, use manufactured long sweep bends with minimum radius of 36 inches in both horizontal and vertical directions.
 7. Separation Between Direct-Buried, Nonencased Ducts: 3 inch minimum for like services, and 6 inch minimum between power and signal ducts.
- E. In precast areas, run conduits in insulation space or in floor topping without crossing conduits, using 3/4 inch maximum conduit size.

3.03 WIREWAYS

- A. Use wireways only where indicated on drawings.
- B. Do not use wireways without prior approval from Engineer.
- C. Do not install wireways through walls or floors.

3.04 INSTALLATION

- A. Cap conduits after installation to prevent entry of debris.
- B. Conceal raceways by enclosing within finished walls, ceilings, and floors, unless otherwise indicated.
- C. Provide watertight conduit system where installed in wet places, underground or where buried in masonry or concrete.
- D. Use threaded hubs when entering top of enclosures.
- E. Use sealing type locknuts when entering sides or bottom of enclosures.
- F. Install two spare 1 inch conduits from top of each flush mounted panelboard to area above ceiling for future use. On flush mounted panelboards located on first and higher level floors, provide two spare 1 inch conduits from bottom of panelboard to ceiling area of floor below for future use.
- G. Keep raceways at least 6 inch (150 millimeter) away from parallel runs of flues and steam or hot water pipes. Install horizontal raceway runs above water and steam piping.
- H. Install raceways level and square and at proper elevations. Provide adequate headroom.
- I. Complete raceway installation before starting conductor installation.

- J. Support raceway as specified in Section 26 05 29. Provide dissimilar metal separation where metallic conduit materials differ from metallic hangers and supports.
- K. Use temporary closures to prevent foreign matter from entering raceway.
- L. Run concealed raceways with minimum of bends in shortest practical distance considering type of building construction and obstructions, except as otherwise indicated.
- M. Install exposed raceways parallel to or at right angles to nearby surfaces or structural members and follow surface contours as much as practical.
 - 1. Mount exposed horizontal runs as high above floor as possible, and in no case lower than 7 foot above floors, walkways, or platforms in passage areas.
 - 2. Run parallel or banked raceways together, on common supports where practical.
 - 3. Make bends in parallel or banked runs from same center line to make bends parallel. Use factory elbows only where they can be installed parallel; otherwise, provide field bends for parallel raceways.
- N. Join raceways with fittings designed and approved for purpose and make joints tight.
 - 1. Make raceway terminations tight. Use bonding bushings or wedges at connections subject to vibration. Use bonding jumpers where joints cannot be made tight.
 - 2. Use insulating bushings to protect conductors.
- O. Terminations: Where raceways are terminated with locknuts and bushings, align raceway to enter squarely, and install the locknuts with dished part against the box. Use two locknuts, one inside and one outside the box. Use insulating bushings. Provide insulated grounding bushings to terminate ground wire.
- P. Where terminating in threaded hubs, screw raceway or fitting tight into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align the raceway so the coupling is square to box, and tighten chase nipple so no threads are exposed.
- Q. Install pull wires in empty raceways. Use monofilament plastic line having not less than 200 pound (90 kilogram) tensile strength. Leave not less than 12 inch (300 millimeter) of slack at each end of pull wire.
- R. Telephone and Signal System Raceways 2 inch Trade Size and Smaller: In addition to above requirements, install in maximum lengths of 150 foot (45 meters) and with maximum of two 90 degree bends or equivalent. Install pull or junction boxes where necessary to comply with these requirements.
- S. PVC Externally Coated Galvanized Rigid Steel Conduit: Use only fittings approved for use with that material. Field cuts on all male threads of conduit sections, elbows, and nipples shall be protected by application of a conductive, non-corrosive protection. Patch nicks and scrapes in PVC coating after installing conduit. All installers shall be field certified by the PVC Coated manufacturer for installation and provide proof of certification.
- T. Conduit runs extending through areas of different temperature or atmospheric conditions or partly indoors and partly outdoors shall be sealed, drained, and installed in manner preventing drainage of condensed or entrapped moisture into cabinets, motors or equipment enclosures.

3.05 CONDUIT STUB-UPS

- A. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portion of bends is not visible above finished slab.
- B. Transition under floor conduit to PVC coated galvanized rigid steel conduit before rising above floor such that entire vertical riser is PVC coated galvanized rigid steel conduit. Under floor conduit elbows shall be PVC coated galvanized rigid steel

conduit. Extend the PVC coated galvanized rigid steel conduit portion of the stub-up minimum 12 inch above floor or slab.

3.06 CONDUIT BENDS

- A. Make bends and offsets so inside diameter is not reduced. Unless otherwise indicated, keep legs of bend in same plane and straight legs of offsets parallel.
- B. Provide NEMA standard conduit bends, except for conduits containing medium voltage cable, fiber optic cable, or conductors requiring large radius bends.
- C. Provide large radius conduit bends for conduits containing 5 kilovolt and 15 kilovolt cables as follows:

Conduit Trade Size	Bend Radius
2 inch - 2-1/2 inch	24 inch
3 inch - 4 inch	36 inch
5 inch	48 inch

1. Where physical limitations do not permit use of above, conduit bends with radius of at 8 times diameter of largest cable passing through conduit may be used.

3.07 FLEXIBLE CONNECTIONS

- A. Use maximum of 6 foot (1830 millimeter) of flexible conduit for recessed and semi-recessed lighting fixtures.
- B. Terminate conduits at motor terminal boxes, motor operated valve stations or pipe-mounted instruments and other equipment subject to vibration with maximum of 3 foot (915 millimeter) liquidtight flexible metal conduit unless otherwise indicated.
- C. Use liquidtight flexible conduit in wet, damp, and corrosive locations.
- D. Use flexible conduit and connections suitable for hazardous classified locations in hazardous classified locations.
- E. Install separate ground conductor inside flexible conduit connections.
- F. Do not route flexible conduit through walls, floors, ceilings, or roofs.

3.08 FITTINGS

- A. Install raceway sealing fittings according to manufacturer's written instructions. Locate fittings at suitable, approved, accessible locations and fill them with UL-listed sealing compound. Install raceway sealing fittings at following points and elsewhere as indicated:
 1. Where conduits enter or leave hazardous locations.
 2. Where conduits pass from warm locations to cold locations, such as boundaries of refrigerated spaces and air-conditioned spaces.
 3. Where otherwise required by NEC.
- B. Use raceway fittings compatible with raceway and suitable for use and location. For GRS, use threaded conduit fittings, except as otherwise indicated.
- C. Install automatic breather drain fittings according to manufacturers written instructions. Locate fittings to drain conduit system and prevent condensate from entering device enclosures. Install automatic breather drain fittings at following points and elsewhere as indicated. Fittings shall be installed such that condensate is directed away from electrical and mechanical equipment and/or toward sump area or floor drain.
 1. Where vertical seals are installed.
 2. Low points in conduit system.
 3. Where conduits enter panels or junction boxes in damp locations.
 - a. Where conduits enter the top of enclosures, breather drains shall be installed on the lowest portion of enclosure for moisture prevention and drainage.
 4. Where conduits pass from outside of building to inside.
 5. Where conduits pass between rooms that have significant temperature differences.
 6. Below field instruments at junction of flexible and rigid conduit.
 7. Where otherwise required by NEC.
- D. Install wall entrance seal as dictated by application where conduits pass through foundation walls below grade.
- E. Install conduit expansion fittings complete with bonding jumper in following locations.
 1. Conduit runs crossing structural expansion joint.
 2. Conduit runs attached to 2 separate structures.

- 3. Conduit runs where movement perpendicular to axis of conduit may be encountered.
- F. Conduit shall be firmly packed at fitting nearest wall or floor line with Johns-Manville Duxseal to depth of at least 1 inch after wires and cables are pulled in; or, if conduit enters directly into equipment, it shall be fitted with seal and drain fitting to prevent water entering equipment. Provide at the following locations:
 - 1. Conduit entries into Electrical or Control Rooms via the floor
 - 2. Where conduit passes from inside of building to outdoors
- 3.09 GROUNDING
 - A. Ground in accordance with Section 26 05 26.
 - B. Provide grounding connections for raceway, boxes, and components as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening torques specified in UL 486A.
- 3.10 PROTECTION
 - A. Provide final protection and maintain conditions, in manner acceptable to manufacturer and Installer, to ensure that coatings, finishes, and cabinets are without damage or deterioration at Substantial Completion.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC or paint finishes with matching touch-up coating recommended by manufacturer.
- 3.11 CLEANING
 - A. Upon completion of installation of system, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

POWER SYSTEM STUDIES

PART 1 – GENERAL

- 1.01 SUMMARY
 - A. Section Includes:
 - 1. Short circuit study, protective device evaluation study, protective device coordination study, and arc flash study on the 9th Street Pump Station electrical system shown on drawing 007-E-1.
 - 2. System shall be evaluated based on normal utility service and generator emergency service.
 - B. Contractor shall engage services of independent engineering firm for purpose of performing electric power system studies as specified.
 - C. The Electrical Power System Studies shall be performed and the shop drawing shall be submitted and approved prior to submitting the shop drawings for the electrical equipment.
- 1.02 SUBMITTALS
 - A. Study Report:
 - 1. Provide summary of results of power system study in final report.
 - 2. Include:

- a. Description, scope of services, purpose, basis, definition of terms, guide for interpretation of computer printouts, and single line diagram of power system.
 - b. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short circuit duties and commentary regarding same.
 - c. Protective device time versus current color coordination curves, tabulations of relay and circuit breaker trip settings, fuse selection, and commentary regarding same.
 - d. Fault current calculations including definition of terms and guide for interpretation of computer printout.
 - e. Arc flash calculations and tabulation of incident energy level calories /square centimeter (cal/cm²) for each equipment location and recommended personal protective equipment (PPE).
 - B. Submit final database in electronic format (SKM or approved equal).
- 1.03 QUALITY ASSURANCE
- A. Regulatory Requirements:
 - 1. National Electric Code (NEC): Components and installation shall comply with National Fire Protection Association (NFPA) 70.
 - 2. National Electric Safety Code (NESC): Components and installation shall comply with American National Standards Institute (ANSI) C2.
 - 3. Standard for Electrical Safety in the Work Place: National Fire Protection Association (NFPA) 70E.
 - B. Qualifications of engineering firm.
 - 1. Corporately and financially independent engineering organization which can function as unbiased engineering authority, professionally independent of manufacturers, suppliers and installers of equipment or systems studied as specified.
 - 2. Study report shall be signed and sealed by Professional Engineer registered in same State as project location.
 - 3. Engineering organization may be same as testing organization.

PART 2 – PRODUCTS

- 2.01 SOFTWARE
 - A. Studies shall be performed using SKM Power Tools system analysis software, no substitution.
- 2.02 POWER SYSTEM STUDY COMPANIES
 - A. Electric Power Systems
 - B. High Voltage Maintenance
 - C. Introba

PART 3 – EXECUTION

- 3.01 STUDIES
 - A. Studies include following all equipment at 9th Street Pump Station shown on drawing 007-E-1.
 - B. Contractor and company performing the power system studies are responsible for gathering information on the equipment and conductors required to perform the power system studies.
- 3.02 SHORT CIRCUIT STUDY
 - A. Provide complete report with printout data sheets using digital computer type program as part of study.

- B. Include utilities' short circuit contribution, resistance and reactance components of branch impedances, X/R ratios, base quantities selected, and other source impedances.
 - C. Calculate short circuit momentary duty values and interrupting duty values based on assumed 3-phase bolted short circuit at switch gear base medium voltage controller, switchboard, low voltage Motor Control Center (MCC), distribution panelboard, pertinent branch circuit panel, and other significant locations through system. Include short circuit tabulation of symmetrical fault currents and X/R ratios. List with respective X/R ratio each fault location, total duty on bus, and individual contribution from each connected branch.
- 3.03 EQUIPMENT DEVICE EVALUATION STUDY
- A. Provide protective device evaluation study to determine adequacy of circuit breakers, molded case switches, automatic transfer switches, knife switches, controllers, surge arresters, busways, and fuses by tabulating and comparing short circuit ratings of these devices with calculated fault currents. Apply appropriate multiplying factors based on system X/R ratios and protective device rating standards. Notify Engineer of problem areas or inadequacies in equipment due to short circuit currents and provide suggested alternate equipment.
- 3.04 EQUIPMENT DEVICE COORDINATION STUDY
- A. Provide protective device coordination study with necessary calculations and logic decisions required to select or check selection of power fuse ratings, protective relay characteristics and settings, ratios and characteristics of associated current transformers, and low voltage breaker trip characteristics and settings. Objective of study to obtain optimum protective and coordination performance from these devices.
 - B. Include as part of coordination study, medium and low voltage classes of equipment from utility's incoming line protective device down to and including largest rated device in 480 volt MCCs and panelboards. Include phase and ground overcurrent protection as well as settings of other adjustable protective devices.
 - C. Draw time-current characteristics of specified protective devices in color on log-log paper or computer printout. Include with plots complete titles, representative one-line diagram and legends, associated Power Company's relays or fuse characteristics, significant motor starting characteristics, complete parameters of transformers, complete operating bands of low voltage circuit breaker trip curves and fuses. Indicate types of protective devices selected, proposed relay taps, time dial and instantaneous trip settings, transformer magnetizing in-rush and ANSI transformer withstand parameters, cable thermal overcurrent withstand limits, and significant symmetrical and asymmetrical fault currents. Provide coordination plots for phase and ground protective devices on system basis. Provide sufficient number of separate curves to indicate coordination achieved.
 - D. Provide separate selection and settings of protective devices in tabulated form listing circuit identification, Institute of Electrical and Electronics Engineers (IEEE) device number, current transformer ratios and connection, manufacturer and type, range of adjustment, and recommended settings. Tabulate recommended power fuse selection for medium voltage fuses where applied in system. Notify Engineer of discrepancies, problem areas or inadequacies and provide suggested alternate equipment ratings and/or settings.
- 3.05 ARC FLASH STUDY
- A. Provide Incident Energy Study – An incident energy study shall be done in accordance with the IEEE 1584, "IEEE Guide for Performing Arc Flash Hazard Calculations" as referenced in NFPA 70E, "Standard for Electrical Safety in the

Workplace”, in order to quantify the hazard for selection of personal protective equipment (PPE).

- B. Adjust system design to optimize the results of the study as it relates to safety and reliable electrical system operation (e.g. overcurrent device settings, current limiting devices). This includes mitigation, where possible, of incident energy levels that exceed 40 cal/cm². Provide suggested alternate equipment and settings to minimize incident energy levels.
 - C. Provide incident energy level (cal/cm²) for each equipment location and recommended PPE.
 - D. Based on the results of the incident energy study provide and install a warning label (orange <40 cal/cm²) or danger label (red > 40 cal/cm²) for each piece of equipment. The label must be readable in both indoor and outdoor environments and contain the following information:
 - 1. Arc hazard boundary (feet and inches)
 - 2. Working distance (feet and inches)
 - 3. Arc flash incident energy at the working distance (cal/cm²)
 - 4. Voltage rating of the equipment
 - 5. Limited approach distance (feet and inches)
 - 6. Restricted approach distance (feet and inches)
 - 7. Equipment/bus name
 - 8. Date prepared
- 3.06 PROTECTIVE DEVICE CALIBRATION AND ADJUSTMENT
- A. Coordinate with equipment installer.

PANELBOARDS

PART 1 – GENERAL

- 1.01 SUMMARY
 - A. Section Includes:
 - 1. Lighting and power panelboards and associated auxiliary equipment rated 600 Volts and less.
- 1.02 SUBMITTALS
 - A. Product Data: For each type of panelboard, accessory item, and component specified.
 - B. Shop Drawings: For panelboards. Include dimensioned plans, sections, and elevations. Show tabulations of installed devices, major features, and voltage rating. Include following:
 - 1. Enclosure type with details for types other than National Electrical Manufacturers Association (NEMA) 250, Type 1.
 - 2. Bus configuration and current ratings.
 - 3. Short-circuit current rating of panelboard.
 - 4. Features, characteristics, ratings, and factory settings of individual protective devices and auxiliary components.
 - C. Test Results:
 - 1. Indicate and interpret field test results for compliance with performance requirements.
 - D. Operation and Maintenance Manuals:
 - 1. Instruction books and leaflets.
 - 2. Recommended renewal parts list.

- 3. Drawings and information.
- 1.03 QUALITY ASSURANCE
 - A. Items provided under this section shall be listed or labeled by Underwriters Laboratories, Inc. (UL) or other Nationally Recognized Testing Laboratory (NRTL).
 - 1. Term "NRTL" shall be as defined in Occupational Safety and Health Administration (OSHA) Regulation 1910.7.
 - 2. Terms "listed" and "labeled" shall be as defined in National Electrical Code (NEC), Article 100.
 - B. Regulatory Requirements:
 - 1. NEC: Components and installation shall comply with National Fire Protection Association (NFPA) 70.
 - C. Comply with National Electrical Manufacturers Association (NEMA) PB 1.

PART 2 – PRODUCTS

- 2.01 MANUFACTURERS
 - A. Schneider Electric
 - B. Eaton Corporation
- 2.02 PANELBOARD FABRICATION
 - A. Enclosures: Flush- or surface-mounted cabinets as indicated.
 - 1. Refer to Space Environment and Hazardous Ratings Schedule on Drawings for determination of the Exposure type of each space in which panelboard is to be installed. Refer to Material Schedule on Drawings for enclosure material to be utilized within each Exposure type.
 - B. Front: Secured to box with concealed trim clamps, unless otherwise indicated. Front for surface-mounted panelboards shall be same dimensions as box. Fronts for flush panelboards shall overlap box, unless otherwise indicated.
 - C. Directory Frame: Metal, mounted inside each panelboard door.
 - D. Bus: Hard drawn tin plated copper of 98% conductivity.
 - E. Main and Neutral Lugs: Compression type.
 - F. Equipment Ground Bus: Copper, adequate for feeder and branch-circuit equipment ground conductors. Bonded to box.
 - G. Service Equipment Approval: Listed for use as service equipment for panelboards with main service disconnect.
 - H. Future Devices: Equip with mounting brackets, bus connections, and necessary appurtenances, for overcurrent protective device ampere ratings indicated for future installation of devices.
- 2.03 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS
 - A. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
 - B. Doors: In panelboard front, with concealed hinges. Secure with flush catch and tumbler lock, keyed alike.
- 2.04 OVERCURRENT PROTECTIVE DEVICES
 - A. Molded-Case Circuit Breaker: NEMA AB 1, handle lockable.
 - 1. Characteristics: Frame size, trip rating, number of poles, and auxiliary devices as indicated and interrupting capacity rating to meet available fault current.
 - 2. Application Listing: Appropriate for application, including Type SWD for switching fluorescent lighting loads, Type HACR for heating, air-conditioning, and refrigerating equipment and Class B GFCI for pipeline and vessel fixed electrical heating equipment unless otherwise indicated.
 - 3. Circuit Breakers, 200 Amp and Larger: Trip units interchangeable within frame size.

4. Circuit Breakers, 400 Amp and Larger: Field-adjustable long-time, short-time, and instantaneous current settings.
 5. Current Limiters: Where indicated, integral fuse listed for circuit breaker.
 6. Lugs: Mechanical lugs and power-distribution connectors for number, size, and material of conductors indicated.
 7. Series rated circuit breakers not acceptable.
- 2.05 SURGE PROTECTION DEVICES
- A. Provided with the following features:
1. Provide with dedicated service entrance rated disconnecting means to isolate device from system without interrupting service.
 2. IEEE C62.41, selected to meet requirements for service entrance rating.
 3. Protection modes and UL 1449, third edition or latest edition, clamping voltages coordinated with circuit system and circuit voltage.
 4. Factory mounted with UL listed and labeled mounting device.
 5. 200 kiloamp (kA) per phase surge current capacity minimum.
 6. Door mounted diagnostic lights.
 7. Audible alarm, with silencing switch, to indicate when protection has failed. Switch shall be accessible from outside of enclosure and not require enclosure door to be opened to access.
 8. Replaceable modular design.
 9. One Form C contact to indicate suppressor is operational.
 10. Minimum of 10 year warranty.

PART 3 – EXECUTION

- 3.01 INSTALLATION
- A. Install panelboards and accessory items according to NEMA PB 1.1.
 - B. Mounting Heights: Top of trim 74 inch (1880 millimeter) above finished floor, unless otherwise indicated.
 - C. Mounting: Plumb and rigid without distortion of box. Mount flush panelboards uniformly flush with wall finish.
 - D. Circuit Directory: Type directory to indicate installed circuit loads after balancing panelboard loads. Obtain approval before installing.
 - E. Install filler plates in unused spaces.
 - F. Wiring in Panelboard Gutters: Arrange conductors into groups, and bundle and wrap with wire ties after completing load balancing.
- 3.02 IDENTIFICATION
- A. Identify field-installed wiring and components and provide warning signs as specified in Section 800.
 - B. Panelboard Nameplates: Label each panelboard with engraved laminated-plastic or metal nameplates mounted with corrosion-resistant screws.
- 3.03 GROUNDING
- A. Make equipment grounding connections for panelboards.
 - B. Provide ground continuity to main electrical ground bus.
- 3.04 CONNECTIONS
- A. Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A.
- 3.05 FIELD QUALITY CONTROL
- A. Make insulation-resistance tests of each panelboard bus, component, and connecting supply, feeder, and control circuits.
 - B. Make continuity tests of each circuit.

- C. Visual and Mechanical Inspection.
 - 1. Check circuit breaker for proper mounting and compare nameplate data to drawings and specifications.
 - 2. Operate circuit breaker to ensure smooth operations.
 - 3. Inspect case for cracks or other defects.
- D. Balancing Loads: After Substantial Completion, conduct load-balancing measurements and make circuit changes as follows:
 - 1. Perform measurements during period of normal working load as advised by Owner.
 - 2. Perform load-balancing circuit changes outside normal occupancy/working schedule of facility. Make special arrangements with Owner to avoid disrupting critical 24 hr services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 - 3. Recheck loads after circuit changes during normal load period. Record all load readings before and after changes and submit test records.
 - 4. Tolerance: Difference exceeding 20% between phase loads, within panelboard, is not acceptable. Rebalance and recheck as required to meet this minimum requirement.

3.06 CLEANING

- A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

WIRING DEVICES

PART 1 – GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Receptacles, connectors, switches, and finish plates.

1.02 DEFINITIONS

- A. GFCI: Ground-fault circuit interrupter.

1.03 SUBMITTALS

- A. Submittals are not required if one of named manufacturers is furnished. If named manufacturer is not furnished submit Product Data and Samples.
- B. Product Data:
 - 1. For each product specified that is not one of the named manufacturers.
- C. Samples:
 - 1. For devices and device plates for color selection and evaluation of technical features.

1.04 QUALITY ASSURANCE

- A. Items provided under this section shall be listed or labeled by Underwriters Laboratories, Inc. (UL) or other Nationally Recognized Testing Laboratory (NRTL).
 - 1. Term "NRTL" shall be as defined in OSHA Regulation 1910.7.
 - 2. Term "listed" and "labeled" shall be as defined in National Electrical Code (NEC), Article 100.
- B. Regulatory Requirements:
 - 1. NEC: Components and installation shall comply with National Fire Protection Association (NFPA) 70.

- C. Comply with National Electrical Manufacturers Association (NEMA) WD 1.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. Wiring Devices:
1. Bryant Electric, Inc.
 2. GE Company; GE Wiring Devices.
 3. Hubbell, Inc.; Wiring Devices Div.
 4. Killark Electric Manufacturing Co.
 5. Pass & Seymour/Legrand; Wiring Devices Div.
 6. Pyle-National, Inc.; an Amphenol Co.

2.02 RECEPTACLES

- A. Straight Blade and Locking Receptacles: Heavy Duty specification grade.
- B. GFCI Receptacles: Termination type, with integral NEMA WD 6, Configuration 5-20R duplex receptacle. Design units for installation in 2-3/4 inch (70 millimeter) deep outlet box without an adapter.
- C. Isolated Ground Receptacles: Equipment grounding contacts connected only to green grounding screw terminal of device with inherent electrical isolation from mounting strap.
1. Devices: Listed and labeled as isolated ground receptacles.
 2. Isolation Method: Integral to receptacle construction and not dependent on removable parts.
- D. Industrial Heavy Duty Receptacle: Comply with International Electrotechnical Commission (IEC) 309-1 and 309-2.
- E. Color: White unless otherwise indicated or required by Code.

2.03 SWITCHES

- A. Snap Switches: Heavy duty, quiet type.
- B. Color: White unless otherwise indicated or required by Code.

2.04 WALL PLATES

- A. Single and combination types match corresponding wiring devices.
1. Plate Securing Screws: Metal with head color to match plate finish.
 2. Finished Spaces: 0.04 inch (1 millimeter) thick, Type 302, satin finished stainless steel.
 3. Unfinished Spaces: Galvanized steel.
 4. Exterior and wet locations: Weatherproof plates and covers suitable for wet locations while in use.
 - a. Hinged and gasketed cover/enclosure to maintain weather tight seal while the equipment is plugged into it. TayMac or equal.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Outlet Boxes and Fittings: Install outlet and device boxes and associated covers and fittings of materials and NEMA types for each location in conformance with following requirements unless otherwise noted on Drawings:
1. Refer to Space Environment and Hazardous Ratings Schedule on Drawings for determination of the Exposure type of each space in which box is to be installed. Refer to Material Schedule on Drawings for material and NEMA enclosure type to be utilized within each Exposure type.
 2. NEMA 7 in Class I hazardous classified locations. When located in exterior locations or in wet locations provide O-ring/gasket or equivalent making box suitable for outdoor use.

3. NEMA 9 in Class II hazardous classified locations. When located in exterior locations or in wet locations provide O-ring/gasket or equivalent making box suitable for outdoor use.
 4. Metal Door Jambs: Narrow partition boxes with internal ears.
 5. As otherwise indicated and as required by NEC.
 - B. Mounting height as follows unless otherwise shown on Drawings:
 1. Switches: 48 inch above floor.
 2. AC Receptacles and Telephone Outlets: 15 inch above floor or 6 inch above counters, counter back-splashes, and baseboard radiators in finished areas; 48 inch above floor in unfinished areas.
 - C. Install devices and assemblies plumb and secure.
 - D. Install wall plates when painting is complete.
 - E. Do not share neutral conductor on load side of dimmers.
 - F. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical, and grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.
 - G. Protect devices and assemblies during painting.
 - H. Adjust locations at which floor service outlets and telephone/power service poles are installed to suit arrangement of partitions and furnishings.
- 3.02 IDENTIFICATION
- A. Comply with Section 800.
 1. Switches: Where three or more switches are ganged, and elsewhere as indicated, identify each switch with approved legend engraved on wall plate.
 2. Receptacles: Identify panelboard and circuit number from which served. Use machine printed, pressure sensitive, abrasion resistant label tape on face of plate and durable wire markers or tags within outlet boxes.
- 3.03 CONNECTIONS
- A. Connect wiring device grounding terminal to branch circuit equipment grounding conductor.
 - B. Isolated Ground Receptacles: Connect to isolated ground conductor routed to designated isolated equipment ground terminal of electrical system.
 - C. Tighten electrical connectors and terminals according to manufacturers published torque-tightening values. If manufacturers torque values are not indicated, use those specified in UL 486A.
- 3.04 FIELD QUALITY CONTROL
- A. Test wiring devices for proper polarity and ground continuity. Operate each device at least six times.
 - B. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.
 - C. Replace damaged or defective components.
- 3.05 CLEANING
- A. Internally clean devices, device outlet boxes, and enclosures. Replace stained or improperly painted wall plates or devices.

SURGE PROTECTIVE DEVICES FOR LOW-VOLTAGE ELECTRIC POWER CIRCUITS

PART 1 – GENERAL

1.01 DESCRIPTION

- A. Provide effective high energy transient voltage surge suppression, surge current diversion and high frequency noise attenuation in all electrical modes for equipment connected downstream from the facility's meter or load side of the main overcurrent device. Unit shall provide protection against both transient surges under 100 microseconds (μ s) and temporary over voltages (TOV) and swells up to 2 minutes. Connect in parallel with the facility's wiring system.
 - B. Designed and manufactured in the USA by qualified manufacturer of suppression filter system equipment engaged in commercial design and manufacture of such products for minimum of five (5) years.
- 1.02 SUBMITTALS
- A. Product Data:
 - 1. Include rated capacities; shipping, installed and operating weights; furnished specialties; and accessories for each model indicated.
 - B. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
 - C. Operation and Maintenance Data:
 - 1. Surge Protective Devices (SPD).
 - D. Warrantees: Special warrantees specified in this Section.
- 1.03 ENVIRONMENTAL REQUIREMENTS
- A. Storage Temperature. Storage temperature range shall be -40oC to +85oC (-40oF to +185oF).
 - B. Operating Temperature. Operating temperature range shall be -40oC +60oC (-40oF to +140oF).
 - C. Relative Humidity: Operation shall be reliable in an environment with 5% to 95% non-condensing relative humidity.
 - D. Audible Noise: The unit shall not generate any audible noise.
 - E. Magnetic Field: No appreciable magnetic fields shall be generated.
- 1.04 QUALITY ASSURANCE
- A. Systems shall be designed, manufactured, tested and installed in accordance with the following applicable documents and standards:
 - 1. Underwriters Laboratories, Inc. (UL1449 4th edition and UL 1283 5th edition)
 - 2. Canadian Standard Association (CSA)
 - 3. National Electrical Manufacturers Association (NEMA LS1 - 1992)
 - 4. American National Standards Institute / Institute of Electrical and Electronics Engineers ANSI/IEEE (C62.41 – 1991, C62.45 – 1992, and C62.34)
 - 5. Military Standards (MIL-STD 220B)
 - 6. National Electric Code (NEC)
 - 7. National Fire Protection Association (NFPA 70 [NEC], 75 and 78)
 - 8. Federal Information Processing Standards Publication 94 (FIPS PUB 94)
 - 9. Underwriter's Laboratories 248-1

PART 2 – PRODUCTS

2.01 MANUFACTURERS

- A. Current Technology, Inc.

2.02 SURGE PROTECTIVE DEVICE (SPD)

- A. Surge suppressor shall have UL 1449 suppression ratings for each mode of protection, as follows:
 - 1. 480/277 volt, 3 phase "WYE" – 1200 volts.
 - 2. 120/208 volt, 3 phase "WYE" – 800 volts.
 - 3. 480 volt 3 phase "Delta" – 1800 volts

- B. Provide protection in all modes. Seven discrete modes for "WYE" systems, Line-to-Neutral (L-N), Line-to-Ground (L-G) and Neutral-to-Ground (N-G), and six modes for "Delta" systems, Line-to-Line (L-L) and Line-to-Ground (L-G). (See NEMA 2.2.7 & IEEE Std. 1100-1992).
- C. Include a predetermined number of Selenium cells in parallel with arrays of non-linear voltage dependent metal oxide varistors (MOV) to protect against system voltage swells.
- D. The Catastrophic Protection System shall provide TOV and voltage swell protection to the following:
 - 1. TOV – should be capable of surviving and continue to protect critical loads against multiple TOV events (described as 200% nominal voltage by 8 milliseconds (ms).
 - 2. Swell – should be capable of protection against swells up to 180% nominal for 0.7 ohms load for greater than 18,000 cycles.
- E. MOVs tested per ANSI/IEEE C62.33-1982.
- F. Minimum Single Pulse Surge Current Capacity per ANSI/IEEE C62041-1991's standard 8 X 20 μ s current waveform, shall not be less than as follows:
 - 1. Selenium Select SPD (with disconnect) for 100-SPD-1
 - a. 150,000 amps, L-N
 - b. 150,000 amps, L-G min. amps per phase 300,000 (L-N plus L-G)
 - c. 150,000 amps, N-G
 - d. 150,000 amps, L-L
- G. Test system for repetitive sequential ANSI/IEEE C62.41 Category C3 waveforms. Minimum repetitive strikes of 1.2 X 50 μ s, 20 kilovolt (KV) open circuit voltage and 8 X 20 μ s, 10 kiloampere (KA) short circuit current with no more than 10% degradation of clamping voltage at the specified surge current.
- H. Provide an extended range noise tracking filter system between 50 kilohertz (kHz) and 100 megahertz (MHz) with a minimum insertion loss ratio of 50:1 or 34 db over the entire range per NEMA LS-1, 1992, Section 2.2.11. UL 1283 Listed as an Electromagnetic Interference Filter. (Standard insertion loss data obtained utilizing MIL-STD-220B 50 ohm insertion loss methodology).
- I. Minimum continuous operating voltage (MCOV) of any component shall not be less than 115% of nominal operating voltage. MCOV shall be a tested value per section 37.7.3 of UL 1449 3rd Edition.
- J. The primary suppression path shall be Line to Neutral.
- K. All surge current devices shall incorporate low impedance plated busbars. No small gauge round wire, printed circuit boards, silicon avalanche diodes or plug-in connections are acceptable.
- L. Each individual Selenium cell, MOV and capacitor shall be fused so that the failure of any component does not affect the operation or protection of the entire unit.
- M. Enclosure:
 - 1. Refer to Space Environment and Hazardous Ratings Schedule on Drawings for determination of the Exposure type of each space in which SPD is to be installed. Refer to Material Schedule on Drawings for material and NEMA enclosure type to be utilized within each Exposure type.
 - 2. As otherwise indicated and as required by NEC.

2.03 ACCESSORIES

- A. Selenium Select SPD on-line monitoring:
 - 1. MasterMIND Monitoring. One set of status monitoring lights, that will provide visual indication of voltage present to the SPD. The lights shall also indicate when any value of less than 50% suppression protection is available from the SPD.

- a. An audible alarm, a surge counter categorized into three industry recognizable categories, and two sets of Form C contacts for remote monitoring.
- b. Monitoring system shall include a local display to provide a time, date, magnitude, and duration stamp for when the following power quality events occur:
 - 1) Sags (voltage < 90% of nominal)
 - 2) Swells (voltage > 110% of nominal)
 - 3) Surges (voltage > 130% of peak voltage)
 - 4) Dropouts and Outages (power interruptions > 1 cycle)
- c. High Performance Interconnect. Dual shielded, triple insulated multi-core power conductor, UL approved.
- d. System shall be capable of communicating remotely via Modbus TCP over Ethernet and a web interface via Ethernet.

PART 3 – EXECUTION

3.01 SYSTEM TESTING

- A. Factory test before shipment.
 - 1. Testing shall include, but not be limited to production-line tests, quality assurance checks, MCOV, and benchmark clamping voltage tests.
 - 2. A copy of the benchmark clamping tests for each individual SPD shall be included with each unit.
- B. Manufacturer's Field Services:
 - 1. Supplier's or manufacturer's representative for equipment specified herein shall be present at jobsite or classroom designated by Owner for minimum workdays indicated, travel time excluded, for assistance during plant construction, plant startup, and training of Owner's personnel for plant operation. Include:
 - a. 1/2 workday for Installation and Testing Services.
 - b. 1/2 workday for Instructional Services.
 - 2. Supplier or manufacturer shall direct services to system and equipment operation, maintenance, troubleshooting, and equipment and system-related areas other than wastewater treatment process. See Section 01 61 00.
 - 3. Obtain the services of a factory-authorized local service representative to provide the following tests:
 - a. Voltage measurements from L-G, L-N, L-L and N-G (as applicable).
 - b. Impulse injection to verify the system suppression voltage tolerances for all suppression paths. (Note: This testing is separate from any switchgear or other system tests. Completely disconnect the SPD from the switchgear prior to any switchgear or other system tests, including any hi pot testing.)
 - c. Record and compare test results to factory benchmark test parameters supplied with each individual unit.
 - d. Submit a copy of the start-up test results and the factory benchmark testing results to the engineer and the owner for confirmation of proper system function.

3.02 INSTALLATION

- A. Selenium SPDs
 - 1. SPDs shall be installed on load side of the main disconnects.
 - 2. SPDs 150KA per mode and below shall have a dedicated circuit breaker disconnect at the connection point in the electrical distribution equipment. SPDs above 150KA per mode shall be connected directly to the equipment bus. Low impedance (HPI) cable shall be used to connect the SPD to the electrical

distribution equipment. The total cable length between the SPD and the motor control centers and panelboards shall not exceed 10 feet.

3.03 SYSTEM WARRANTY

- A. The SPD system manufacturer shall warranty the entire system against defective materials and workmanship for a period of twenty years for the Selenium Select SPDs.

INTERIOR LIGHTING

PART 1 – GENERAL

1.01 SUMMARY

- A. Section Includes:
1. Interior lighting fixtures
 2. Emergency lighting units
 3. Exit lights
 4. Accessories.

1.02 DEFINITIONS

- A. Emergency Lighting Unit: Fixture with integral emergency battery-powered supply and means for controlling and charging battery. Also known as an emergency light set.
- B. Fixture: Complete lighting unit, exit sign, or emergency lighting unit. Fixtures include lamps and parts required to distribute light, position and protect lamps, and connect lamps to power supply. Internal battery-powered exit signs and emergency lighting units also include battery and means for controlling and recharging battery. Emergency lighting units include ones with and without integral lamp heads.
- C. Average Life: Time after which 50% fails and 50% survives under normal conditions.

1.03 SUBMITTALS

- A. Product Data
1. Describe fixtures, lamps, ballasts, and emergency lighting units. Arrange Product Data for fixtures in order of fixture designation.
 2. Include data on features and accessories and following:
 - a. Outline drawings indicating dimensions and principal features of fixtures.
 - b. Electrical Ratings and Photometric Data: Certified results of laboratory tests for fixtures and lamps.
 - c. Battery and charger data for emergency lighting units.
- B. Maintenance and Operating Data (O&M):
1. Maintenance data for fixtures to include operation and maintenance information.

1.04 QUALITY ASSURANCE

- A. Items provided under this section shall be listed or labeled by UL or other Nationally Recognized Testing Laboratory (NRTL).
1. Term "NRTL" shall be as defined in OSHA Regulation 1910.7.
 2. Terms "listed" and "labeled" shall be as defined in National Electrical Code, Article 100.
 3. Special Listing and Labeling: Provide fixtures for use in damp or wet locations, underwater, and recessed in combustible construction that are specifically listed and labeled for such use. Provide fixtures for use in hazardous (classified) locations that are listed and labeled for specific hazard.
 4. National Electrical Code (NEC): Components and installation shall comply with National Fire Protection Association (NFPA) 70.
- B. Coordinate fixtures, mounting hardware, and trim with ceiling system and other items, including work of other trades, required to be mounted on ceiling or in ceiling space.

1.05 WARRANTY

- A. Special Warranty for Batteries: Submit written warranty executed by manufacturer agreeing to replace rechargeable system batteries that fail in materials or workmanship within the specified warranty period.

1. Special Warranty Period: Manufacturer's standard but not less than 10 years after date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for last 9 years.

PART 2 – PRODUCTS

2.01 FIXTURES AND FIXTURE COMPONENTS

- A. Metal Parts: Free from burrs, sharp corners, and edges.
- B. Sheet Metal Components: Steel, except as indicated. Form and support to prevent warping and sagging.
- C. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position.
- D. Reflecting Surfaces: Minimum reflectance as follows, except as otherwise indicated:
 1. White Surfaces: 85%.
 2. Specular Surfaces: 83%.
 3. Diffusing Specular Surfaces: 75%.
 4. Laminated Silver Metallized Film: 90%.
- E. Lenses, Diffusers, Covers, and Globes: 100% virgin acrylic plastic or water white, annealed crystal glass, except as otherwise indicated.
 1. Plastic: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 2. Lens Thickness: 0.125 inch (3 millimeter) minimum; except where greater thickness is indicated.
- F. Fixture Support Components: Comply with Section 26 05 29.
 1. Single-Stem Hangers: 1/2 inch (12 millimeter) steel tubing with swivel ball fitting and ceiling canopy. Finish same as fixture.
 2. Twin-Stem Hangers: Two, 1/2 inch (12 millimeter) steel tubes with single canopy arranged to mount a single fixture. Finish same as fixture.
 3. Rod Hangers: 3/16 inch (5 millimeter) minimum diameter, zinc-plated, threaded steel rod.
 4. Hook Hanger: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.
- G. Light Emitting Diodes (LED):
 1. Non-recessed Fixtures
 - a. LED rated for 100,000 hour life.
 - b. Embedded controls shall allow fixture to communicate with other nLight enabled controls included but not limited to dimmers, switches, occupancy sensors, and photocontrols
 - c. 0-10V dimming.
 - d. Damp rated.
 - e. CSA Certified.
 - f. UL listed driver.

2.02 FINISHES

- A. Manufacturer's standard, except as otherwise indicated, applied over corrosion-resistant treatment or primer, free of streaks, runs, holidays, stains, blisters, and similar defects.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Set units plumb, square, and level with ceiling and walls, and secure according to manufacturer's written instructions and approved Shop Drawings. Support fixtures according to Section 26 05 29.
- B. Support for Suspended Fixtures: Brace pendants and rods over 48 inch (1200 millimeter) long to limit swinging. Support stem-mounted, single-unit, suspended fluorescent fixtures with twin-stem hangers. For continuous rows, use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of chassis, including one at each end.
- 3.02 CONNECTIONS
 - A. Ground lighting units. Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A.
- 3.03 FIELD QUALITY CONTROL
 - A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
 - 1. Verify normal operation of each fixture after fixtures have been installed and circuits have been energized with normal power source.
 - 2. Give advance notice of dates and times for field tests.
 - 3. Provide instruments to make and record test results.
 - B. Replace fixtures that show evidence of corrosion during Project warranty period.
- 3.04 ADJUSTING AND CLEANING
 - A. Clean fixtures after installation. Use methods and materials recommended by manufacturer.
 - B. Adjust aimable fixtures to provide required light intensities.

SEISMIC RESTRAINTS FOR EQUIPMENT

PART 1 - GENERAL

- 1.01 SUMMARY
 - A. This Section includes seismic restraints for non-structural components.
- 1.02 DESIGN REQUIREMENTS
 - A. Design for dead, live, wind, and seismic loads as required by Illinois Building Code.
 - B. Venice Pump Station Seismic Criteria
 - 1. Risk Category: III
 - 2. Importance Factor: 1.25
 - 3. Mapped Spectral Response Accelerations:
 - a. Ss: 0.443
 - b. S1: 0.158
 - 4. Site Class: D
 - 5. Site Coefficients:
 - a. Fa: 1.446
 - b. Fv: 2.284
 - 6. Spectral Response Coefficients:
 - a. Sds: 0.427
 - b. Sd1: 0.240
 - 7. Design Category: D
 - C. Bowman Pump Station Seismic Criteria
 - 1. Risk Category: III

2. Importance Factor: 1.25
 3. Mapped Spectral Response Accelerations:
 - a. S_s : 0.458
 - b. S_1 : 0.161
 4. Site Class: D
 5. Site Coefficients:
 - a. F_a : 1.434
 - b. F_v : 2.278
 6. Spectral Response Coefficients:
 - a. S_d : 0.438
 - b. S_{d1} : 0.145
 7. Design Category: D
- D. Centralia Pump Station Seismic Criteria
1. Risk Category: III
 2. Importance Factor: 1.25
 3. Mapped Spectral Response Accelerations:
 - a. S_s : 0.571
 - b. S_1 : 0.184
 4. Site Class: D
 5. Site Coefficients:
 - a. F_a : 1.343
 - b. F_v : 2.231
 6. Spectral Response Coefficients:
 - a. S_d : 0.511
 - b. S_{d1} : 0.274
 7. Design Category: D
- E. Grays Farm Pump Station Seismic Criteria
1. Risk Category: III
 2. Importance Factor: 1.25
 3. Mapped Spectral Response Accelerations:
 - a. S_s : 0.435
 - b. S_1 : 0.156
 4. Site Class: D
 5. Site Coefficients:
 - a. F_a : 1.452
 - b. F_v : 2.289
 6. Spectral Response Coefficients:
 - a. S_d : 0.421
 - b. S_{d1} : 0.238
 7. Design Category: D
- F. 9th Street Pump Station Seismic Criteria:
1. Risk Category: III
 2. Importance Factor: 1.25
 3. Mapped Spectral Response Accelerations:
 - a. S_s : 0.458
 - b. S_1 : 0.161
 4. Site Class: D
 5. Site Coefficients:
 - a. F_a : 1.434
 - b. F_v : 2.278
 6. Spectral Response Coefficients:

- a. Sds: 0.438
- b. Sd1: 0.145

7. Design Category: D

1.03 SUBMITTALS

A. Shop Drawings:

- 1. Seismic restraint details including number, size, and location.
- 2. Catalog cuts and data sheets.

B. Seismic calculations, stamped by a Professional Engineer registered in the State of Illinois, showing adequacy of bolt sizing and type. Calculations shall be furnished for anchors on restraint devices, cable, and rigidly mounted equipment. Calculations shall specify anchor bolt type, embedment, concrete compressive strength, minimum spacing between anchors, and minimum distances of anchors from concrete edges. Seismic analysis must indicate calculated dead loads, derived loads, and materials utilized for connections to equipment and structure. Analysis must detail anchoring methods, bolt diameter, embedment and/or weld length.

1.04 INTENT

- A. It is the intent of this specification to provide restraint of non-structural components. Restraint systems shall withstand the stipulated seismic accelerations applied through the component center of gravity. The Work of this Section includes the following:
- 1. Seismic restraints for isolated equipment, ductwork, piping, and conduit.
 - 2. Seismic restraints for non-isolated equipment, ductwork, piping, and conduit.
 - 3. Certification of seismic restraint installation.

1.05 DEFINITIONS

- A. The term "equipment" will be used throughout this specification. It includes all non-structural components within the facility and/or serving this facility. Equipment buried underground is excluded but entry of services through the foundation wall shall be included. The term "equipment" shall refer (but not be limited to) all process, HVAC, plumbing, and electrical equipment, ductwork, piping, and conduit specified in Divisions 23, 26, and 40.
- B. Positive attachment shall be defined as a support location with a cast-in or wedge type expansion anchor, a double-sided beam clamp, a welded or through bolted connection to the structure.
- C. Transverse Bracing – Restraint(s) applied to limit motion perpendicular or angular to the centerline of the equipment, pipe, duct, or conduit.
- D. Longitudinal Bracing – Restraint(s) applied to limit motion along the centerline of the equipment, pipe, duct, or conduit.

1.06 RESPONSIBILITIES

- A. The manufacturer of seismic restraints shall determine the sizes and locations of seismic restraints, provide the seismic restraints, provide installation instructions, proper drawings, and shall certify correctness of installation upon completion.
- B. Internally isolated equipment in lieu of specified restraint systems must include certification by the equipment manufacturer that the internal system meets the specified system restraint criteria. In the event that the equipment is internally restrained, the entire unit assembly must be seismically attached to the structure. This attachment and certification thereof shall be by this Section.
- C. Unless otherwise specified, all isolated equipment and all piping, ductwork, and conduit shall be seismically restrained in accordance with requirements contained herein.
- D. All nonisolated mechanical equipment, piping, ductwork, and conduit shall be adequately secured to the structure.

- E. Each piece of isolated equipment shall receive a minimum of four (4) all-directional restraints, located as close to the equipment corners as practical. All seismic restraint devices shall maintain the equipment in a captive position and not short circuit isolation devices during normal operating conditions.
- F. Seismic restraints shall be anchored to the floor or ceiling from which the equipment, piping, ductwork, or conduit is supported from. Do not anchor seismic restraints to wall unless approved by Engineer.

1.07 COORDINATION

- A. Coordinate layout and installation of seismic-restraint devices with other construction.
- B. Coordinate size and location of concrete housekeeping bases.
- C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 - PRODUCTS

2.01 DESCRIPTION

- A. Design of hardware and devices such as beam clamps, anchor bolts, cable, and cast-in-place plates must be by this Section's supplier to ensure seismic compliance and certification.
- B. Unless otherwise specified, all hardware shall be stainless steel.

2.02 MANUFACTURERS

- A. Mason Industries, Inc.
- B. Or equal.

2.03 PRODUCTS

- A. Seismic Cable Restraints: Galvanized steel aircraft cables sized to resist seismic loads with a minimum safety factor of two and arranged to provide all-directional restraint. Cables must be prestretched to achieve a certified minimum modulus of elasticity. Cable end connections shall be steel assemblies that swivel to final installation angle and utilize two clamping bolts to provide proper cable engagement. Cables must not be allowed to bend across sharp edges. Cable assemblies shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California verifying the maximum certified load ratings. Cable assemblies shall be Type SCB at the ceiling and at the clevis bolt, SCBH between the hanger rod nut and the clevis or SCBV if clamped to a beam all as manufactured by Mason Industries, Inc.
- B. Stud Wedge Anchors: Full diameter wire, not from undersized wire that is "rolled up" to create the thread. The stud anchor shall also have a safety shoulder which fully supports the wedge ring under load. The stud anchors shall have an evaluation report number from the I.C.B.O Evaluation Service, Inc. verifying its allowable loads. Drill-in stud wedge anchors shall be type SAS as manufactured by Mason Industries, Inc.
- C. Female Wedge Anchors: Manufactured from full diameter wire, and shall have a safety shoulder to fully support the wedge ring under load. Female Wedge Anchors shall have an evaluation report number from the I.C.B.O Evaluation Service, Inc. verifying to its allowable loads. Drill-in female wedge anchors shall be type SAB as manufactured by Mason Industries, Inc.
- D. Welded steel shapes shall conform to ASTM A36.
- E. Resilient Components: ¾-inch thick, replaceable, shock-absorbing neoprene inserts.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Install and anchor seismic-control products according to manufacturer's written instructions and authorities having jurisdiction.

- B. Overstressing of the building structure must not occur because of overhead support of equipment. Contractor must submit loads to the structural engineer of record for approval. Generally bracing may occur from:
 - 1. Flanges of structural beams.
 - 2. Cast-in-place inserts or wedge anchors.

3.02 SEISMIC CONTROL

- A. Mount equipment on structural-steel bases or concrete inertia bases.
- B. Lateral Supports: Install lateral supports for floor mounted mechanical equipment such as tanks, pumps, etc.
- C. Seismic Restraint of Piping:
 - 1. Seismically restrain piping listed below:
 - a. Fuel oil piping, gas piping, and compressed air piping that is 1" I.D. or larger.
 - b. Piping located in mechanical equipment rooms that is 1 1/4" I.D. and larger.
 - c. Other piping 2 1/2" diameter and larger.
 - 2. Transverse piping restraints shall be at 40' maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.
 - 3. Longitudinal restraints shall be at 80' maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.
 - 4. For fuel oil and all gas piping transverse restraints must be at 20' maximum and longitudinal restraints at 40' maximum spacing.
 - 5. Transverse restraint for one pipe section may also act as a longitudinal restraint for a pipe section of the same size connected perpendicular to it if the restraint is installed within 24" of the elbow or TEE or combined stresses are within allowable limits at longer distances.
 - 6. Hold down clamps must be used to attach pipe to all trapeze members before applying restraints in a manner similar to clevis supports.
 - 7. Branch lines may not be used to restrain main lines.
- D. Seismic Restraint of Duct Work:
 - 1. Seismically restrain duct work as listed below:
 - a. Rectangular ducts with cross sectional area of 6 sq.ft. or larger.
 - b. Round ducts with diameters of 28" or larger.
 - c. Flat oval ducts the same as rectangular ducts of the same nominal size.
 - 2. Transverse restraints shall occur at 30' intervals or at both ends of the duct run if less than the specified interval. Transverse restraints shall be installed at each duct turn and at each end of a duct run.
 - 3. Longitudinal restraints shall occur at 60' intervals with at least one restraint per duct run. Transverse restraints for one duct section may also act as a longitudinal restraint for a duct section connected perpendicular to it if the restraints are installed within 4' of the intersection of the ducts and if the restraints are sized for the larger duct. Duct joints shall conform to SMACNA duct construction standards.
 - 4. The ductwork must be reinforced at the restraint locations. Reinforcement shall consist of an additional angle on top of the ductwork that is attached to the support hanger rods. Ductwork is to be attached to both upper angle and lower trapeze.
 - 5. A group of ducts may be combined in a larger frame so that the combined weights and dimensions of the ducts are less than or equal to the maximum weight and dimensions of the duct for which bracing details are selected.
 - 6. Walls, including gypsum board non bearing partitions, which have ducts running through them may replace a typical transverse brace. Provide channel framing around ducts and solid blocking between the duct and frame.
- E. Seismic Restraint of Electrical Services:
 - 1. Electrical conduit 2 1/2" in diameter and larger shall be restrained.

2. Electrical bus ducts, cable trays and ladder trays shall be restrained.
 3. Transverse restraints shall occur at 30' intervals or both ends if the electrical run is less than the specified interval. Transverse restraints shall be installed at each electrical services turn and at each end of the electric run.
 4. Longitudinal restraints shall occur at 60' intervals with at least one restraint per electric run. Transverse restraints for one electric section may also act as a longitudinal restraint for a duct for an electric section connected perpendicular to it if the restraints are installed within 4' of the intersection of the electric run and if the restraints are sized for the larger electric run.
 5. Rigid floor mounted equipment must have a resilient media between the equipment mounting hole and the anchor bolt. Anchor bolts shall be designed in accordance with seismic forces from building code.
 6. Wall mounted panels shall be mounted with bushings. Floor mounted panels shall be mounted on bushings and anchor bolts.
- F. All mechanical equipment shall be seismically restrained.
- 3.03 SEISMIC RESTRAINT EXCLUSIONS
- A. Piping:
1. Gas piping less than 1" inside diameter.
 2. Piping in mechanical rooms less than 1 1/4" inside diameter.
 3. Other piping less than 2 1/2" inside diameter.
 4. Piping suspended by individual hangers 12" or less as measured from the top of the pipe to the bottom of the support where the hanger is attached. However, if the 12" limit is exceeded by any hanger in the run, seismic bracing is required for the run. The 12" exemption applies for trapeze supported systems if the top of each item supported by the trapeze qualifies.
- B. Duct Work:
1. Rectangular and square and ducts that are less than 6 square feet in cross sectional area.
 2. Oval ducts that are less than 6 square feet in cross sectional area based on nominal size.
 3. Round duct less than 28" in diameter.
 4. Duct suspended by hangers 12" or less in length as measured from the top of the duct to the point of attachment to the structure. Hangers must be attached within 2" of the top of the duct with a minimum of two #10 sheet metal screws. If the 12" limit is exceeded by any hanger in the run, seismic bracing is required for the run.
- C. Electrical:
1. Conduit less than 2 1/2" diameter suspended by individual hanger rods.
 2. Conduits suspended by individual hangers 12" or less as measured from the top of the conduit to the bottom of the support where the hanger is attached. However, if the 12" limit is exceeded by any hanger in the run, seismic bracing is required for the run. The 12" exemption applies for trapeze supported systems if the top of each item supported by the trapeze qualifies.
- D. Suspended Equipment:
1. Fan powered equipment weighing less than 50 lbs. and rigidly connected to the supply side of the duct system and supported with a minimum of 4 hanger rods.

PROCESS CONTROL SYSTEM (PCS) GENERAL PROVISIONS

PART 1 – GENERAL

1.01 SUMMARY

- A. Section covers general provisions and requirements for all work necessary for engineering, furnishing, installing, adjusting, testing, documenting, programming, and starting-up the process control system.
- B. Unless otherwise noted, the System Integrator shall assume responsibility for specification sections:
 - 1. Process Control System – Testing Section 40 61 21.
 - 2. Process Control System – Training Section 40 61 26.
 - 3. Process Control System – O&M Data Section 40 61 30.
 - 4. Control Panels Section 40 67 15.
 - 5. Instrumentation of Process Systems Section 40 70 00.
 - 6. Panel Mounted Instruments Section 40 78 00.

1.02 REFERENCES AND ABBREVIATIONS

- A. References:
 - 1. ANSI: American National Standards Institute
 - 2. CSA: Canadian Standards Association
 - 3. EN: European Standards (generic)
 - 4. FM: Factory Mutual
 - 5. IEC: International Electrotechnical Commission
 - 6. IEEE: Institute of Electrical and Electronics Engineers
 - 7. ISA: International Society of Automation
 - 8. NEC: National Electrical Code
 - 9. NEIS: National Electrical Installation Standards
 - 10. NEMA: National Electrical Manufacturers Association
 - 11. NIST: National Institute of Standards and Technology
 - 12. NRTL: Nationally Recognized Testing Laboratory
 - 13. NFPA: National Fire Protection Agency
 - 14. OSHA: Occupational Safety and Health Administration
 - 15. UL: Underwriters Laboratory
- B. Abbreviations:
 - 1. HMI: Human/Machine Interface
 - 2. I&C: Instrumentation and Controls
 - 3. I/O: Input / Output
 - 4. LOS: Line of Sight
 - 5. PC: Personal Computer
 - 6. PCN: Process Control Network
 - 7. PCS: Process Control System
 - 8. PLC: Programmable Logic Controller
 - 9. OIU: Operator Interface Unit
 - 10. SCADA : Supervisory Control and Data Acquisition
 - 11. UPS: Uninterruptible Power Supply

1.03 DEFINITIONS

- A. Process Control System: an integrated system of PLCs, computers, instruments, devices, process control networks, software, application engineering, and ancillary equipment for monitoring and control of process systems.

- B. System Integrator: an organization whose principal function is to design, program, configure, manufacture, install, and service the PCS. Who shall assume responsibility for: detail design, manufacture, installation, configuration, technically advising on and certifying correctness of installation, testing, adjusting, documenting, commissioning, and training of the PCS.

1.04 SUBMITTALS

- A. Shop Drawings including the following information:

1. General:
 - a. Drawings shall include ancillary devices such as terminal strips, relays, fuses, utility lights and receptacles, fans, heaters, etc.
 - b. Typical drawings for multiple circuits or systems are not acceptable.
2. Panel Layout Drawings - Showing all panel mounted devices to scale and dimensioned and shall include a legend.
 - a. Include cross-references to a bill of material for components used.
 - b. Component designations shall match those used on elementary schematic diagrams and physical component labeling required per Section 40 67 15.
 - c. Prepare in general accordance with NFPA 79, Annex D.
 - d. PLC equipment layout including processing equipment, I/O components, power supplies, and peripheral devices.
 - e. PCS equipment layout including detailed enclosure layouts for servers, switches, and communications systems.
3. Elementary Schematic Diagrams – Ladder type circuit diagrams showing:
 - a. Control devices shown between vertical lines that represent control power wiring, with the left line representing control circuits common and right representing operating coils common except where permitted by Clause 9 of NFPA 79.
 - b. Control devices shall be shown on numbered horizontal lines (rungs) between the vertical lines.
 - c. Drawings shall include a cross referencing scheme used in conjunction with each relay, output device, limit switch, and other devices so that any contact related to a device can be readily located on the drawing.
 - d. Component designations shall be included for all devices, with the same designations used on panel layout drawings.
 - e. Each panel terminal within a terminal strip shall be numbered; when multiple terminal strips exist, each shall be given a unique identification. Terminal strip identification shall be included on panel layout drawings.
 - f. All wires shall be numbered; wire numbers shall be applied to labels in accordance with Section 40 67 15. Wiring and devices external to panel shall be clearly identified.
 - g. Control devices shall utilize the symbology depicted in NFPA 79 and IEEE315.
 - h. Switch symbols shall be shown with utilities turned off and devices in their normal starting condition. Include control settings on the diagrams when available.
4. Panel Interconnection Diagrams – Showing all signal and power wiring for external connections to control panels. Wire and cable tags information shall be provided to Contractor in an electronic format for use in physical wire and cable tagging.
 - a. Drawings prepared on a per control panel basis.
 - b. Show interconnecting wiring between field devices and control panel.
 - c. Interconnecting wiring shall include wire and cable tag numbers.

- d. Field device information shall include device tag and description, signal description, signal electrical characteristics, and range.
 - e. Control panel information shall include terminal strip identification and terminal number.
 - f. Drawings shall indicate source of control signal power.
 - g. Prepare drawings in accordance with requirements of NFPA 79.
 - 5. Electrical power, UPS, Grounding, and DC Power Schematics for all equipment.
 - 6. Heat calculations for all enclosures.
 - 7. UPS sizing calculations including all power loads connected to the UPS.
 - 8. Test reports.
 - B. List of special tools (including software) required for all components of the Process Control System.
 - C. Product Data:
 - 1. Catalog Information - Provide catalog information and descriptive literature on all equipment associated with the PCS.
 - 2. Product Data (Specification) Sheets – Provide product data sheets for each component provided under this Section noting all specific features for each specific component (e.g., scale range, materials of construction, special options included). Product Data Sheets shall follow General ISA S20 format.
 - 3. Software user manuals for all applications, including operating system and custom software, describing programming methods and procedures, utilities, diagnostics, documentation, and system support functions.
 - D. Prepare and submit startup schedule, coordinated with overall Construction Schedule including the following:
 - 1. Factory acceptance test(s).
 - 2. Review of wiring sign-off forms by Owner/Engineer.
 - 3. I/O checkout by System Integrator.
 - 4. Plant startup.
 - 5. Training.
 - 6. Post-startup services.
 - E. Test Outline and Procedure Submittal
 - 1. Submit a detailed description of each required test procedure and demonstration.
 - 2. Test descriptions shall be in sufficient detail to fully describe the specific tests to be conducted to demonstrate conformance with these Specifications.
 - 3. Provide detailed step-by-step in-factory and field test procedure in accordance with Section 40 61 21. Include proposed test documentation and sign-off sheets and punch list forms.
 - F. Operation and Maintenance (O&M) Data:
 - 1. Submit in accordance with Section 40 61 30.
 - 2. Fully documented copies of all application programs.
 - 3. Setup instructions.
 - G. Record Drawings: Submit in accordance with Section 40 61 30.
- 1.05 QUALITY ASSURANCE
- A. Contractor shall engage the services of a qualified System Integrator.
 - B. Equipment and firmware shall be of the latest model or version that is compatible with each other at the time of the Notice to Proceed.
 - C. Like items of equipment shall be end products of single manufacturer to achieve standardization for maintenance, spare parts, operation, and service.
 - D. Progress meeting(s) shall be held during the project:
 - 1. Submit progress meeting schedule, submittal schedule, and activity schedule for coordination between Owner/Engineer, Contractor, and Systems Integrator.

2. The first progress meeting shall be held within 30 days of date of the contract start date.
3. Progress meetings shall be held at a site designated by Owner with representatives of the Owner, Engineer, Contractor, Application Engineer, and System Integrator in attendance.
4. Purpose of progress meetings is to obtain Owner/Engineer's clarification on intent of contract documents during submittal preparation and prior to OIU and PLC software configuration. Progress meeting(s) shall cover following:
 - a. Review of functional descriptions describing equipment operation.
 - b. Owner/Engineer selection of options.
 - c. Owner/Engineer review of documentation.

1.06 **SYSTEM INTEGRATOR RESPONSIBILITY**

- A. System Integrator shall inspect equipment furnished prior to shipment to project sites.
- B. System Integrator shall coordinate work with Contractor to ensure that:
 1. All components provided are properly installed.
 2. All components provided are properly configured.
 3. The proper type, size, and number of control wires with conduits are provided.
 4. Proper electric power circuits are provided for all components and systems.
- C. System Integrator shall be responsible for coordination of voltage levels and signal types for signals connected to Process Control System. Provide relays, signal isolators, termination or pull-up resistors, signal conditioners or other devices as required for proper interfacing and operation of non-compatible devices.
- D. System Integrator shall supply all OIU and PLC software fully configured for the project requirements.
- E. System Integrator shall be responsible for establishing proper communication of all control system components.
- F. System Integrator shall be responsible for the operational testing of the OIU and PLC software programs.
- G. Modifications to existing control equipment.
 1. Provide equipment necessary to affect changes to existing control equipment as shown on drawings and specified.
 2. Provide interposing relays and current-to-current isolation relays only as required to affect signal interfacing with non-compatible devices.
 3. Modify documents of existing control equipment to reflect new as-built conditions and submit revised drawings.
- H. Contractor shall furnish Owner with copy of all configured PLC application programs after on- site acceptance test.

1.07 **APPLICATION ENGINEERING SERVICES**

- A. Application Engineering Services shall be provided by System Integrator.
- B. Application Engineering Services shall include the following:
 1. Develop written loop descriptions from the Process Control Descriptions of Section 40 67 15. These loop descriptions will define the proposed operation and control of the plant equipment and systems affected by the work of this project.
 2. Develop sample graphic screen layouts.
 3. Organize and lead a workshop with the Owner to review and discuss:
 - a. The written loop descriptions for operation and control of systems affected by the work on this project.
 - b. Sample graphic screen layouts.
 - c. Navigation alternatives and approaches.
 - d. Trending requirements.
 - e. Alarm and event requirements.

- f. Security requirements.
 - 4. Prepare draft meeting notes of workshop(s) including any mutually agreed-upon changes to the loop descriptions and the sample graphics presented.
 - 5. Develop application software associated with the project. Application software will be based on the standards established with the Owner during the pre-programming phase of the project.
 - 6. Install and test application software developed by Application Engineer. Modify tested software to incorporate changes agreed to between the Owner and Application Engineer.
 - 7. Develop standard trends and set up custom trend features.
 - 8. Prepare an operation and maintenance manual for the new application software. The manual will serve as the basis for training provided by Application Engineer.
 - 9. Provide on-site training of Owner's personnel in the use of the application software configurations provided.
 - 10. Deliverables:
 - a. One electronic copy of program documentation on flash drive or other media acceptable to Owner.
 - b. Three hardcopy and one electronic copy of O&M Manual prepared for this project. O&M manual electronic copy will be MSWord with supporting material in PDF.
- 1.08 WORK FOR HIRE
- A. All configuration, programming, setup, or other software functions (Software) performed on intelligent devices provided as part of this Project is to be considered "Work for Hire" under the 1976 Copyright Act as amended (Title 17 of the United States Code). The Software shall be owned by Owner and shall be turned over to Owner fully documented as the work is completed.
 - B. Owner intends only to obtain the Software for its own use.
 - C. Owner will not prevent the Software supplier from reuse of the Software concepts and ideas for other projects. Any reuse of the Software concepts and ideas generated under this Project is solely the responsibility of the Software supplier. The Software supplier shall defend, indemnify, and hold harmless Owner from all claims, damages, and expenses (including reasonable litigation costs), arising out of any use, misuse, or misapplication of Software concepts and ideas.
- 1.09 WARRANTY
- A. System Integrator shall warranty the Process Control System for a period of one year from the date of Substantial Completion.

PART 2 – PRODUCTS

- 2.01 SYSTEM INTEGRATOR EXPERIENCE REQUIREMENT
- A. The System Integrator shall meet the following requirements:
 - 1. Be regularly engaged in the design, installation, and servicing of lift station process control systems.
 - 2. Have previously executed a minimum of five lift station PCS projects of similar size and complexity to this project using the PLC and HMI platforms included in this project.
 - 3. Have previously successfully executed wireless and wired networked projects of comparable size and complexity to this project.
 - 4. The person(s) performing the required field work shall have a minimum of five years experience on similar PLC-based systems.
 - 5. Provide an on-site control systems engineer for commissioning, functional testing, start-up, and training of the Process Control System. The individual shall have

authored and commissioned control logic for no fewer than three projects of similar or greater complexity and shall have a demonstrated proficiency in authoring logic in PLC Function Block Language.

6. Upon request of Owner and in addition to other specified requirements, Contractor shall provide a minimum of five System Integrator references to confirm compliance with these requirements.

2.02 EQUIPMENT, SYSTEMS, AND SERVICES

- A. Equipment, systems, and services provided under this Section shall conform to the following requirements.
 1. UL 508 - Standards for Safety, Industrial Control Equipment.
 2. NEMA ICS 1 - General Standards for Industrial Control and Systems.
 3. NEMA ICS 2 - Standards for Industrial Control Devices, Controllers and Assemblies.
 4. NEMA ICS 3 - Industrial Systems.
 5. NEMA ICS 6 - Enclosures for Industrial Controls and Systems.
 6. NEMA ICS 250 - Enclosures for Electrical Equipment.
 7. NFPA 79 - Electrical Standard for Industrial Machinery
 8. UL 698A Intrinsic Safe Circuits.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Contractor shall install and wire Process Control System equipment in accordance with System Integrator's and instrument manufacturer's written instructions and approved submittals.
- B. PCS components shall be grounded in accordance with NEC requirements.
- C. The System Integrator shall supervise final power and signal connections by Contractor to all equipment provided or interfacing with the Process Control System.
- D. Instrumentation transmitters, displays, and other indicators shall be orientated such that they are easily readable and accessible from operating locations.
- E. System Integrator shall field calibrate and completely configure equipment and instruments at time of startup on loop-by-loop basis and make adjustments necessary to place equipment in satisfactory operation.

3.02 FIELD QUALITY CONTROL

- A. Protection during construction.
 1. Throughout the contract Contractor shall provide protection for materials and equipment against loss or damage and the effects of weather. Prior to installation, store items in indoor, dry locations. Provide heating in storage areas for items subject to corrosion under damp conditions. Specific storage requirements shall be in accordance with the System Integrator's recommendations.
- B. Cleaning and touch-up painting.
 1. Keep the premises free from accumulation of waste material or rubbish. Upon completion of work, remove materials, scraps, and debris from premises and from interior and exterior of all devices and equipment. Touch-up scratches, scrapes, or chips in interior and exterior surfaces of devices and equipment with finishes matching the type, color, consistency, and type of surface of the original finish.
- C. Panels and panel-mounted equipment.
 1. Panels and panel-mounted devices shall be assembled as completely as possible at the System Integrator's facility. No work other than field terminations and correction of minor defects or minor transit damage shall be required at the job site.
- D. Inspections.

1. System Integrator shall provide services of qualified service personnel to supervise and inspect equipment installation to ensure system is installed in accordance with System Integrator's recommendations.
2. All materials, equipment, and workmanship shall be subject to observation at any time by Engineer's representatives.

PROCESS CONTROL SYSTEM (PCS) – TESTING

PART 1 – GENERAL

1.01 SUMMARY

- A. Section includes in-factory and field testing requirements.
- B. Testing of Process Control System (PCS) in conjunction with following Sections.
 1. Section 40 67 15 Control Panels

1.02 SUBMITTALS

- A. In addition to submittal requirements of Section 40 61 13, provide the following:
 1. Test Results:
 - a. Pass/fail status of all digital I/O.
 - b. Results of analog I/O testing.
 2. Miscellaneous:
 - a. Detailed step-by-step in-factory and field test procedure at least 6 wks in advance of scheduled test date. Include sign-off sheets and punch list forms and description of configurations to be tested.
 - b. Complete inventory of equipment to be tested at factory including make, model, and serial number. Label each piece of equipment.

PART 2 – SERVICES

2.01 PREPARATION

- A. In-Factory Testing Aids and Equipment:
 1. Provide following documents.
 - a. One copy of submittals applicable to equipment to be tested.
 - b. One copy of Drawings and Specifications, with Addenda and Change Orders.
 - c. One copy of test procedure.
 - d. Complete inventory of equipment to be tested including make, model, and serial number.
- B. Meet following criteria prior to start of test.
 1. Complete submittals and resolve disputes, if any.
 2. Include PLC processor, PLC network interface, and OIU display in testing.
 3. Coordinate test date agreeable to each party.
- C. Schedule:
 1. At end of test, meet to review list of deficiencies. Engineer will indicate those items which must be corrected prior to shipment.
 2. Confirm, in writing, times and dates 2 weeks before tests.

2.02 IN-FACTORY INSPECTION AND PLC I/O TESTING

- A. In-factory inspection and testing shall be performed at site of panel fabrication.
- B. Owner shall be invited to witness inspection and testing.
- C. PLC panel shall pass in-factory inspection and testing prior to shipment to job site.
- D. In-Factory Inspection.
 1. In-factory inspection will verify following in accordance with approved submittals:
 - a. Panel dimensions.

- b. Equipment layout.
 - c. Wiring.
 - d. Wire and terminal identification.
- 2. Verify proper access to equipment for maintenance.
- 3. Verify proper access to field wire termination points.
- 4. Inspect for neatness of wiring and wire harness construction.
- E. In-Factory Testing and Demonstration.
 - 1. Install PLC programming software to permit following:
 - a. Diagnostic test of PLC processor to assure proper run mode operation.
 - b. Diagnostic test of remote I/O to assure proper operation.
 - c. Inspection of PLC data table to allow viewing of discrete input on/off status.
 - d. Inspection of PLC data table to view register contents when inputs are tested at 0, 4, 12, and 20 mAdc.
 - e. Forcing of all digital outputs.
 - f. Generation of 4, 12, and 20 mAdc signals for all analog outputs.
 - 2. Test as follows:
 - a. Verify equipment against inventory lists.
 - b. Run hardware diagnostics.
 - c. Testing of all input and output (I/O) signals at terminal strip used for field terminations.
 - 1) Test change of state for all discrete inputs.
 - 2) Test analog inputs at 0, 4, 12, and 20 mAdc.
 - 3) Manipulate PLC data table or use forces to test response of all discrete output signals.
 - 4) Manipulate PLC data table to test response of all analog output signals at 4, 12, and 20 mAdc.
 - 5) Demonstrate change of state at Operator Interface Unit.
 - 3. Correct any deficiencies discovered prior to shipment to jobsite.
- F. Documentation
 - 1. Prepare in-factory inspection and testing sign-off document. Document shall include following as a minimum.
 - a. Project description and number.
 - b. Company name for tester and Owner.
 - 1) Section labeled "In-Factory Inspection", with listing of items to be inspected as described above.
 - 2) For each item, include area for initials of tester and Owner representative indicating passing of inspection.
 - 3) Include area for handwritten notes of any corrections required.
 - c. Section labeled "In-Factory Testing", with listing of items to be tested as described above.
 - 1) For each item, include area for initials of tester and Owner representative indicating passing of inspection. Include separate line for I/O point to be tested.
 - 2) Include area for handwritten notes of any corrections required.

2.03 FIELD I/O AND SOFTWARE TESTING

- A. General:
 - 1. Field testing is intended to check installation of PLC panels in addition to providing a diagnostic check of field equipment and wiring.
 - 2. Testing shall begin after PLC has been installed and all terminations are complete.
 - 3. Use PLC configuration utilized for In-Factory Testing.

4. Test as follows:
 - a. Run hardware diagnostics.
 - b. Testing of all input and output (I/O) signals by activation or injection of signal at field device.
 - 1) Digital input signals:
 - a) For all equipment run signals, test by on/off operation of equipment. If operation of equipment is deemed inadvisable by Owner or PLC supplier due to potential process upset, inaccessibility of generating device, hazard to personnel or other factors, test by jumpering of motor starter auxiliary contact or other source of run signal.
 - b) For all alarm or status signals, test by activation of device generating alarm. If generation of alarm is deemed inadvisable by Owner or PLC supplier due to potential process upset, inaccessibility of generating device, hazard to personnel or other factors, test by jumpering of alarm contact at nearest accessible location to generating device.
 - c) For signals designated as spare, test by jumpering of signal at PLC panel field termination point.
 - d) Demonstrate change of state in PLC data table.
 - e) Demonstrate change of state at Operator Interface Unit.
 - 2) Digital or Relay output signals:
 - a) Manipulate PLC data table or use forces to test response of all discrete output signals.
 - b) Verify proper response of other devices in loop to signals.
 - c) For signals designated as spare, test by checking signal at PLC panel field termination point.
 - 3) Analog input signals:
 - a) Verify impedance capabilities of transmitting device has not been exceeded by installation of PLC.
 - b) Disconnect transmitting device and inject 0, 4, 12, and 20 mAdc into loop.
 - c) Demonstrate proper response to various signals in PLC data table.
 - d) Demonstrate change of value at SCADA HMI.
 - e) Demonstrate change of value at operator interface terminal.
 - f) Verify proper response of other devices in analog loop to various signals.
 - g) For signals designated as spare, test by injection of signal at PLC panel field termination point.
 - 4) Analog output signals:
 - a) Verify impedance capabilities of analog outputs are not exceeded.
 - b) Generate 4, 12, and 20 mAdc signals for all analog outputs through PLC data table.
 - c) Demonstrate change of value at SCADA HMI.
 - d) Demonstrate change of value at operator interface terminal.
 - e) Verify proper response of other devices in analog loop to various signals. Verify proper loop current through measurement.
 - f) For signals designated as spare, test by measuring of signal at PLC panel field termination point.
5. Documentation
 - a. Prepare field testing sign-off document. Document shall include following as a minimum:
 - 1) Project description and number.

- 2) Company name for Owner and PLC supplier.
- 3) For each I/O point, include area for initials of PLC supplier and Owner representative indicating passing of inspection. Include separate line for I/O point to be tested.
- 4) Include area for handwritten notes of any corrections required.
6. Problem field devices or wiring.
 - a. Provide written documentation of any problems encountered with Owner's existing field devices or wiring during testing.

PART 3 – EXECUTION

3.01 PERFORMANCE

- A. Test PLC and Operator Interface Unit consistent with Drawings and Specifications.

PROCESS CONTROL SYSTEM (PCS) – TRAINING

PART 1 – GENERAL

1.01 SUMMARY

- A. Section includes process control system training requirements.
- B. Include training on the following subjects:
 1. Overview of equipment and how it interacts with field panels, instruments, and other processes.
 2. Operation and use of control programs residing at each PLC and HMI.
 3. Care-taking procedures for PLCs.
 4. Overview of plant communications hardware and equipment.

1.02 ABBREVIATIONS AND REFERENCES

- A. HMI Human Machine Interface
- B. OIU Operator Interface Unit
- C. PLC Programmable Logic Controller
- D. SCADA Supervisory Control And Data Acquisition

1.03 SUBMITTALS

- A. See Section 40 61 13 for submittal requirements.

PART 2 – PRODUCTS (Not Used) PART 3 – EXECUTION

3.01 OPERATION AND MAINTENANCE TRAINING

- A. Testing programs used to isolate faults to a functional area.
- B. Theory, logic flow, physical hardware construction, and interface connections of each device.
- C. Diagnostic procedures and use of any testing equipment. Theory, testing, and troubleshooting procedures for any special testing equipment.
- D. Operation of submersible pump monitoring systems.
- E. Programming routines and procedures available for performing maintenance and performance testing on duty and standby equipment.
- F. Present short operator's course to ensure students understand operator functions and interfaces. Explain displays and printouts so students understand how information is derived, when it is presented incorrectly, and use of guidelines to differentiate between software and hardware problems.

3.02 INSTRUMENT TRAINING

- A. General principle of operation.
- B. Calibration schedule.

- C. Calibration procedure.
 - D. Calibration equipment required (if required).
 - E. Recommended spare parts.
 - F. Recommended replacement schedule of consumable parts (e.g. reagents, filters, probe tips) and replacement procedure.
 - G. General care and maintenance with special consideration to all instruments that may require cleaning such as level elements, etc.
- 3.03 OIU AND PLC TRAINING
- A. OIU functionality.
 - B. How key components work; shall include, but not be limited to:
 - 1. Entering of set points.
 - 2. Using Dialer alarm matrix.
 - 3. Acknowledging and clearing alarms.
 - 4. Accessing and customizing trend displays.
 - C. Block diagram of how PLC program works.

PROCESS CONTROL SYSTEM (PCS) – O&M DATA

PART 1 – GENERAL

- 1.01 SUMMARY
- A. Section includes requirements for Operations and Maintenance (O&M) data for Process Control System.

PART 2 – PRODUCTS

- 2.01 HARDWARE MANUALS
- A. General:
 - 1. Provide instructions for O&M of overall system and individual devices.
 - 2. Provide level of detail so experienced electronics technician can understand them. Convey understanding of how systems operate and provide sufficient procedures for O&M. Use abbreviated tabular data such as charts, tables, checklists, and diagrams whenever practical, in lieu of written text. Make drawings and tables integral part of manuals.
 - 3. Standard hardware manuals are acceptable if data sheets are included indicating specific equipment provided.
 - B. Organization and Content:
 - 1. Introduction Section: Brief explanation of function of equipment covered. Be concise and do not include detailed descriptions. Provide quick orientation to use and purpose of manual and its relationship to system and equipment.
 - 2. Safety Precautions: Major hazards to personnel and equipment particular to equipment or jobs covered. Intersperse specific hazard information, cautions or warning notes at appropriate points throughout other sections of manual.
 - 3. Physical Description: Size, dimension, weight, special attachments, and physical orientation or clearances for installation and operation. Identify special environmental requirements such as temperature limits, humidity, or other limitations.
 - 4. Functional Description: Describe how various functions operate together to create desired results. Include block diagrams and flow diagrams for clarification and understanding. Provide text and diagrams which support each other.

5. Operating procedures: Include maintenance oriented operating procedures for individual equipment so maintenance personnel will be able to verify proper operation.
 - a. Describe each device or assembly in detail with regard to technical or theoretical operation. Describe each circuit and mechanical mechanism. Cross-reference descriptions so functions of each piece of equipment are covered.
 - b. Applicable checkout, troubleshooting, servicing, removal and replacement, and in-place repair procedures. Provide written procedures for every adjustment point of equipment.
6. Checkout Procedures: Verify satisfactory operation of system, subsystem, or unit as applicable. If checkout requires detailed step-by-step procedure, include such procedures. Indicate why checkout is performed and what conditions are to be satisfied.
7. Troubleshooting Procedures: Explain how to isolate faulty components. Sequence troubleshooting procedures in logical progression from malfunction indication to location of faulty component(s). Indicate special connections or test equipment required for troubleshooting.
8. Servicing Requirements: Cleaning, lubricating, replenishing, and other housekeeping and preventive maintenance procedures applying to particular equipment. Reference applicable manuals which describe various servicing procedures.
9. Diagrams: Schematic diagrams, logic diagrams, and associated data necessary for maintenance personnel to trace circuits, make continuity checks, and troubleshoot inoperative or malfunctioning circuits. Provide pin wiring diagrams and cabling and plug tables showing to-and-from wiring information. Provide symbol chart where necessary to explain graphic symbols appearing on diagrams.
10. Parts Lists: Provide clear indication from equipment to replaceable component. Identify each component part with original manufacturer's name and part number. Parts lists may be tabulated or supplied in form of engineering or manufacturing drawings.

2.02 SOFTWARE AND CONFIGURATION MANUALS

- A. Provide complete, organized, and standardized documentation. Structure documentation so each level develops different degree of detail. Begin with broad approach (Systems Manual), focus on smaller pieces of overall system (Subsystem Documentation), and fine detail (Program Documentation).
- B. Systems Manual: Describe overall content of systems software. Describe what is included in software and not how components function. Provide global view of system and complete description of interaction of various software subsystems. Include the following:
 1. Table of contents.
 2. Overall narrative of system including special techniques and general philosophies.
 3. Block diagram showing subsystem interaction.
 4. List of subsystems including brief discussion of purpose of each.
 5. List of programs included, categorized by subsystem, to which each belongs.
 6. Description of files or tables within system which are not unique to any subsystem. Files or tables used uniquely within subsystem may be defined therein.
- C. Cold Boot Manual and Boot Disks: Provide detailed instructions and bootstrap software for restoring all configured equipment to normal operation in the event of an

- equipment crash. Document all soft and hard points used, both in programming code and in Excel format.
- 2.03 SYSTEM CONFIGURATION DRAWING AND MANUALS
- A. System configuration drawing showing Process Control System equipment including PLC, OIU, and local area network hardware. Show cabling and interconnection between system components.
 - B. Configuration data manual describing how the final system is configured. Describe unique data and system parameters.
- 2.04 DRAWINGS
- A. Provide following for Process Control System elements.
 - 1. Block Diagram: Diagram showing major Process Control System components. Identify components by manufacturer and model number. Show interconnecting cables diagrammatically.
 - 2. Power and Grounding Interconnection Diagrams:
 - a. Power diagrams shall detail interconnections from power source through power conditioning equipment, to process control system equipment.
 - b. Grounding diagram shall illustrate grounding philosophy and implementation.
 - 3. Interconnecting Wiring Diagrams: Show Process Control System elements, interconnecting cables and wiring terminations, and terminations to interacting elements and subsystems. Number terminations. Label terminations for circuits extending outside PLC assemblies.
 - a. Coordinate external circuit portion of diagram with work specified under Division 26.
 - b. Nomenclature for external connections shall match that used in the Contract Documents.
 - 4. Shop Drawings for Process Control System equipment such as panels, consoles, and cabinets.

CONTROL PANELS

PART 1 – GENERAL

- 1.01 SUMMARY
- A. Section includes control panel enclosure, hardware and wiring requirements.
- 1.02 ABBREVIATIONS AND REFERENCES
- A. NEC: National Electrical Code
 - B. NEIS: National Electrical Installation Standards
 - C. NEMA: [National Electrical Manufacturers Association](#)
 - D. NFPA: National Fire Protection Agency
 - E. UL: Underwriters Laboratories
- 1.03 SUBMITTALS
- A. See Section 40 61 13 for submittal requirements.
- 1.04 DELIVERY, STORAGE, AND HANDLING
- A. Deliver panels and enclosures to their final locations in protective wrappings, containers, and other protection that will exclude dirt, moisture and prevent damage from construction operations. Remove protection only after equipment is made safe from such hazards and is ready for immediate installation.
 - B. Store panels and enclosures in a clean, dry location.
- 1.05 MAINTENANCE
- A. Extra Materials:

1. Furnish extra materials matching products installed, as described below packaged with protective covering for storage, dated and identified with labels describing contents.
 - a. Provide minimum of 2 or 10%, whichever is greater, of each type fuse used on project.
 - b. Provide minimum of 2 or 10%, whichever is greater, of each type relay used on project.
 - c. Provide minimum of 1 or 10%, whichever is greater, of each type pilot light replacement bulb used on project.

PART 2 – PRODUCTS

2.01 GENERAL REQUIREMENTS

- A. Panels shall be constructed using factory-fabricated enclosures.
- B. Follow device manufacturer's written installation requirements for layout of panels for devices being installed within control panels.
- C. Provide a minimum of 25% free back panel space for future expansion unhindered by current devices, wiring, etc.
- D. Provide a minimum of 25% free terminal blocks of each type used in each panel. This is in addition to planned spare wiring terminations. Spares shall be shown on panel drawings.
- E. The panel builder shall be a current Underwriters laboratories listed UL-698A (panel located in an unclassified location with intrinsically safe circuit extensions into a hazardous location) industrial control panel builder. Panel builder shall present its follow-up service procedure file number on submittals. The panel shall be UL listed and/or recognized where applicable and shall be constructed in accordance with the most current edition of UL-698A and the NEC. A serialized UL-698A label shall be applied to all control panels prior to shipment to the Project site.
- F. Arrange panel to allow all conduits for intrinsically safe wiring to enter the panel enclosure within the intrinsically safe section of the panel. Provide separate terminal strips for intrinsically safe wiring entering and leaving the panel.
- G. Install instruments and devices plumb and wire panels at panel shop or other facility prior to shipment to jobsite.
- H. Standard Signal Interfaces:
 1. Unless otherwise specified, discrete input and output signals shall conform to the following:
 - a. Isolated non-powered (dry) contact closure.
 - b. Dry contacts shall be powered from panel or device receiving signal.
 - c. PLC based outputs shall be provided with an interposing relay when any of the following conditions apply:
 - 1) Potential in-rush current exceeds 75% of rated capacity of the I/O Module.
 - 2) The current requirement of the driven device is insufficient to fully engage the output module consistently.
 - 3) The voltage required to drive the output is incompatible with the output module.
 2. Unless otherwise specified, analog input and output signals shall conform to the following:
 - a. 4-20 mAdc.
 - b. For 2-wire, loop-powered transmitters, provide regulated, fused, and isolated 24Vdc power supply at panel for driving of devices. Size power supply for 30% minimum spare capacity minimum.

- c. Where isolation is required for interfacing with equipment supplied, provide necessary I/I converters. Provide I/I converters where impedance capabilities of new or existing signal transmitter will be exceeded by addition of PLC input.

I. Wiring:

1. In addition to Division 26, NEC, and NEMA requirements wiring shall conform to following:
 - a. Power: 12 AWG stranded minimum, type MTW, 600V.
 - b. Control: 16 AWG stranded minimum, type MTW, 300V.
 - c. Analog Signal: Twisted pair, 18 AWG, Beldon 8760 or equal.
2. Wire color code:
 - a. AC neutral conductor: White.
 - b. AC hot conductor: Black.
 - c. Grounding conductor: Green.
 - d. AC control conductor, powered from within panel: Red.
 - e. AC control conductor, powered from remote source: Orange.
 - f. DC (+) power conductor, discrete signal: Blue.
 - g. DC (-) power conductor, discrete signal: Blue with white stripe.
 - h. DC control conductor, discrete signal: Blue.
 - i. Twisted pair cable (+) signal conductor, analog signal: White.
 - j. Twisted pair cable (-) signal conductor, analog signal: Black.
 - k. Intrinsically safe wiring: Light Blue.
3. Design control panels to keep 480Vac power, 120Vac power and discrete signals, and analog and other low voltage signals separated.
 - a. Do not run 480Vac power, 120Vac power and discrete signals, or analog or other low voltage signals in the same conduit or wire-duct.
 - b. Where 480Vac power, 120Vac power and discrete signals, or analog or other low voltage signals must cross, they shall do so at right angles.
4. Wiring within wire duct:
 - a. Wherever feasible plastic wire duct with cover shall be used for routing of wire within control panel.
 - b. Size wire duct to be no more than 50% full.
 - c. Maintain 2" clearance between wire duct and terminals.
5. Wiring outside of wire duct.
 - a. Wiring outside of ducts shall be restrained by use of plastic wire-ties.
 - b. Restrain wiring every six inches (minimum).
 - c. Provide abrasion protection for wires passing through holes or across abrasive metal edges.
 - d. Adhesive type wire fasteners shall not be used. Hard screw type shall be employed.
6. Each cable shall be labeled near its termination point.
7. Color-coded multi-conductor cable or multi-pair cable shall be labeled on overall jacket near its point of fan-out. Each pair of a multi-pair cable, when not color-coded, shall be labeled at its termination point in addition to the overall jacket.
8. Labels shall be machine-printed wrap-around types with tag visible from front without removal of wire from termination.

J. Terminations:

1. Wiring within control panel shall be continuous and terminated only at terminal blocks or equipment terminals. Splices or butt connectors shall not be used within panel.
2. No more than two wires shall be terminated at any one terminal.

3. Make external connections by way of numbered terminal blocks on numbered terminal strips.
 4. When signals are powered from a remote location, switched terminal blocks shall be used where conductors enter or leave a panel.
 5. When signals are powered from within panel, fused terminal blocks shall be used where conductors enter or leave a panel.
 6. Provide integral bussing system on terminal block array where more than two terminations require common source or drain connection. Jumpered terminations are not acceptable.
 7. Provide knife disconnect-type terminal blocks with test sockets for all analog loops.
 8. Include provisions for grounding of shields on shielded twisted pair cables entering or leaving panel. Cable shields shall be grounded at terminal block end only. Shields shall run entire length of cable within panels. Running of twisted pairs without shields within panels is not acceptable.
 9. Provide separate terminal strips for each of the following types of signals.
 - a. 120Vac power circuits.
 - b. 120Vac discrete signals.
 - c. 12Vdc, 24Vdc or 48Vdc discrete signals.
 - d. Analog signals.
 - e. Serial or parallel digital communication signals.
 - f. Intrinsically safe circuits.
- K. Power Distribution:
1. Provide circuit breaker on power supply entering panel.
 2. Provide single-phase surge suppression/line conditioner, sized for total panel loadings (Benden, Isotrol) between circuit breaker and 120Vac power distribution block.
 3. Provide monitoring relay on incoming power supply to indicate presence of utility power to the PLC. Utility Power, UPS Status, and Surge Protection Device (SPD) status shall be continuously monitored by SCADA system.
 4. Provide separately fused power supply to each major panel component.
 5. Additional panel requirements.
 - a. Provide separately fused power circuits for panel powered devices entering panel from field. Provide separate circuit for each device. Devices may be 5-Amp fused terminal blocks.
 - 1) Solenoid actuated valves
 - 2) Loop powered transmitters
 - 3) 120Vac switched cord and receptacles
 - 4) Relays
 - b. Include digital transient surge suppressor/varistor installed in parallel with output contact at terminal strip for each PLC output signal driving an inductive load including:
 - 1) Relays.
 - 2) Solenoids.
 - 3) Motor starters.
 - 4) Motors.
- L. PLC input and outlet module connections:
1. Input and output signals for process equipment serving the same function shall be assigned to separate I/O Modules so that failure of any one module does not disable an entire unit process. E.g. failure of one card shall not prevent every blower from running.

2. Except for 4-wire instruments, all analog loops shall be powered from respective process control panel.
 3. 120 volts alternating or 24 volts direct current for Process Control System inputs shall be sourced from respective process control panel.
 4. 120 volts alternating or 24 volts direct current for Process Control System outputs shall be sourced from respective location receiving control signal.
- M. Labels and Nameplates:
1. Panel Designation:
 - a. Provide equipment tags with name and tag number shown on the Drawings and Specifications.
 - b. Fastened with stainless steel screws or suitable adhesive where required to maintain panel NEMA rating.
 2. Front of panel mounted devices.
 - a. Provide nameplate for each front of panel device with descriptive phrase using nomenclature as listed on Drawings and Specifications.
 - b. Laminated white plastic with 3/16-in. high black characters on white background except for emergency stop switches which shall have black text on yellow background.
 - c. Fastened with stainless steel screws or suitable adhesive where required to maintain panel NEMA rating.
 3. Rear of panel mounted devices.
 - a. Provide nametag for each rear of panel device with labels used on panel drawings.
 - b. Thermo-embossed or laser printed with 1/8-in. high black characters on clear or white background or laminated white plastic with 3/16-in. high black characters.
 - c. Self-adhesive backing.
- N. Steel Panel Finish:
1. Remove mill scale, grease, and oil.
 2. Primer thickness shall be 0.8 mil., minimum.
 3. Finish coat shall be two-part epoxy or baked dry powder, 3-mil., minimum dry film thickness.
 4. Color: Standard manufacturer's finish.
- O. Conveniences:
1. UPS receptacle – Provide simplex non-GFCI receptacle for plug in of UPS where applicable. Receptacle shall be labeled “120VAC FOR UPS ONLY”.

2.02 ENCLOSURES

- A. Manufacturers
1. Hoffman.
 2. Saginaw.
 3. Hammond.
 4. Rittal.
- B. Refer to Space Environment and Hazardous Ratings Schedule on Drawings for determination of the Exposure type of each space in which enclosures are to be installed. Refer to Material Schedule on Drawings for materials to be utilized within each Exposure type. Enclosures shall conform to the NEMA ratings given on the drawings and specified herein.
- C. In addition to NEMA standards, conform to the following requirements:
1. Minimum metal thickness: 14 Ga.
 2. Equip with rubber-gasketed doors with continuous metal hinges. Equip doors with 3-point lockable latches.

3. NEMA 4X enclosures shall be furnished with door gaskets.
 4. Size to adequately dissipate heat generated by equipment mounted in or on panel.
 - D. Prior to final fabrication of panels, verify layout of front-of-panel devices with respect to rear-of-panel devices. Maintain minimum of 3 inches clearance between door and sub-panel mounted devices.
- 2.03 9TH STREET PUMP STATION LEVEL CONTROL PANEL

- A. Panel
 1. Indoor Enclosure.
 2. NEMA 12.
 3. Wall Mount - Single Door.
 4. Dimensions (Nominal): 36"H x 24"W x 12"D
 5. 120Vac Power Supply.
- B. Front of Panel Mounted Devices
 1. Power Light (White).
 2. PanelView OIU.
- C. Rear of Panel Mounted Devices
 1. CompactLogix PLC.
 2. Surge Protector
 3. 24Vdc Power Supply.
 4. Intrinsically Safe Barriers.
 5. Cooling fan with thermostat.
 6. Relays and timers (as required).
 7. Circuit breakers and fuses (as required).
- D. PLC I/O signals

EQUIPMENT	FUNCTION	SIGNAL TYPE	
		DATA 1	DATA 2
Analog Inputs		4-20mAdc	
Wet Well	Level	0-16	ft
Discrete Inputs		24Vdc	
Utility Power	Failure	Alarm	Normal
Surge Protector	Failure	Alarm	Normal
Uninterruptible Power Supply	Failure	Alarm	Normal
Wet Well	High Level	Alarm	Normal
Wet Well	Low Level	Alarm	Normal
Pump 1	In Auto	In Hand/Off	In Auto
Pump 1	Overload	Alarm	Normal
Pump 1	Seal Fail	Alarm	Normal
Pump 1	Overtemp	Alarm	Normal
Pump 1	Running	Not Running	Running
Pump 2	In Auto	In Hand/Off	In Auto

EQUIPMENT	FUNCTION	SIGNAL TYPE	
		DATA 1	DATA 2
Pump 2	Overload	Alarm	Normal
Pump 2	Seal Fail	Alarm	Normal
Pump 2	Overtemp	Alarm	Normal

Pump 2	Running	Not Running	Running
Discrete Outputs		24Vdc	
Pump 1	Required	Stop	Start
Pump 2	Required	Stop	Start
Pump 1	Failure	Not Failed	Failed
Pump 2	Failure	Not Failed	Failed
Wet Well	Low Level	Not Low	Low
Wet Well	High Level	Not High	High

A. Functional Description

1. The 9th Street Pump Station is a two-pump stormwater lift station designed to elevate runoff to a spillway. Wetwell level is monitored by a submersible level element, with a pair of high/low backup ball floats.
 - a. The Operator will set Lead Start, Lag Start, and All Off level set-points for the station, configured between the High and Low Float elevations.
 - b. If the wet well level rises above the High Float or drops below the Low Float for an adjustable onset delay (initially 30 seconds), the PLC will output the appropriate signal to the station Monitor Panel for dial-out and locally alarm that the level sensor has failed. Station operation will continue using the ball floats, with the High Float replicating the Lag Start set-point and the Low Float replicating the All Off set-point. The Operator may choose via the OIU to disable subsequent outputs to the monitor panel after the initial dial-out alarm has occurred.
2. The 9th Street Pumps are a pair of submersible centrifugal pumps located in the wet well, with constant speed motor starter panels. Each panel includes a Hand/Off/Auto selector switch and contains a motor protection relay for the generation of pump Seal Fail and Overtemp conditions.
 - a. With a starter panel in "Hand", the associated pump will energize and run continuously. PLC control will be inhibited. "Hand" is intended for maintenance purposes only.
 - b. With a starter panel in "Off", the associated pump will remain de-energized. PLC control will be inhibited. "Off" is intended for maintenance purposes only.
 - c. With a starter panel in "Auto", the associated pump will be controlled by the PLC. Manual and Automatic modes will be available at the OIU.
 - 1) In Manual, an Operator can call the pump to Start and Stop from the OIU.
 - 2) In Automatic, the pump will be assigned a Lead or Lag sequence position. The Operator can configure pumps in Automatic to switch sequence positions on a set schedule (initially once per week), at the conclusion of a pumping event (level returns below All Off), or to remain in their current position indefinitely. If a pump is removed from Automatic, the remaining pump becomes Lead.
 - a) When station level rises to the Lead Start set-point for an onset delay (Operator- adjustable, initially 15 seconds) the Lead pump will be called to run. The pump will energize and run until the level drops below the All Off set-point.
 - b) If station level rises to the Lag Start set-point for the onset delay, both pumps will be called to run until the level drops below the All Off set-point.
 - 3) A watchdog timer (initially 10 seconds) will track from the moment a pump is called to run to the moment running feedback is received from the motor

starter aux contact. If running feedback is not received, the pump is alarmed for Fail to Start.

- 4) Pump failure (due to Fail to Start, Overload, Overtemp, or Seal Fail) will move the pump to Manual mode and send an alarm output to the Monitor Panel for dial-out. The pump must be manually returned to Automatic by an Operator after addressing the failure.
 3. The PLC panel will monitor its own power quality, including the presence of incoming Utility power, surge protector failure, and UPS failure.
 4. The OIU will display station status including wet well level, pump run and control mode (Hand, Auto, Manual) status, and any active alarm conditions on the main page.
 - a. Wet well level control points will be displayed alongside a graphical and textual readout of well level. High and Low float alarms will be grey normally, and red in alarm condition.
 - b. De-energized pumps will be grey. Pumps waiting to run due to onset delay will be blue. Running pumps will be red. Alarming pumps will be flashing amber.
 - c. Selection of individual components will lead to detailed pages:
 - 1) Wet Well
 - a) The detailed wet well level page will include a level trend display, with maximum viewable history as determined by the Owner – at minimum store well level up to one year, with displays for the previous day, week, month, and year.
 - b) Operator may select wet well level control points used for pump operation at this screen.
 - 2) Pumps
 - a) Each pump will have a detailed display for total runtime, field switch Hand/Off/Auto position, OIU switch Manual/Automatic position, sequence (Lead/Lag) position, and a pump alarm breakdown (Fail to Start, Seal Fail, Overtemp, and Overload alarms).
 - 3) Alarms
 - a) Detailed alarm history screen will show all stored active, acknowledged, and cleared alarms. Operator will be able to view, interact with, and filter alarms.
 - b) The alarm screen will be accessible from any other screen at all times.
- 2.02 9TH STREET PUMP 1 AND PUMP 2 STARTER PANELS (TYPICAL OF 2)
- A. Panel
 1. Indoor Enclosure
 2. NEMA 12
 3. Wall Mount – Single Door
 4. Dimensions (Nominal): 30"H x 24"W x 12"D
 5. 480Vac Power Supply
 - B. Front of Panel Mounted Devices
 1. Selector Switch – Pump Hand/Off/Auto
 2. Elapsed Time Meter
 3. Pilot Light – Pump Running (Red)
 4. Pilot Light – Pump Overload (Amber)
 5. Pilot Light – Pump Seal Fail (Amber)
 6. Pilot Light – Pump Overtemp (Amber)
 7. Pushbutton – Motor Protection Relay Reset
 - E. Rear of Panel Mounted Devices

1. Magnetic Motor Controller with Overload
2. Control Power Transformer
3. Motor Protection Relay (Existing, relocated)
4. Circuit breakers, fuses, and interposing relays as required.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Install and wire in accordance with equipment/instrument manufacturer's written instructions, approved submittals, applicable requirements of the NEC, NEIS, codes, and recognized industry practices.
- B. Coordinate any required concrete pad dimensions with enclosure dimensions.
- C. Install control panels in locations indicated on Drawings and in accordance with manufacturer's written instructions and approved submittals.
- D. Touch-up panel finish if marred during installation using manufacturer's paint matching enclosure.
- E. Each Panel shall have three sets of "as built" final circuit drawings.
- F. In-Factory testing shall conform to Section 40 61 21.
- G. Perform field testing in accordance with Section 40 61 21 upon completion of installation, wiring and field inspection.

3.02 IDENTIFICATION

- A. Provide equipment identification marker complete with equipment name and tag number. Markers shall be engraved plastic laminate, white with black core (letter color), letter size 1 inch. Fasten with self-tapping stainless steel screws, or with contact type permanent adhesive where screws cannot or should not penetrate substrate.

INSTRUMENTATION OF PROCESS SYSTEMS

PART 1 – GENERAL

1.01 SUMMARY

- A. Section summarizes required field instruments and initial parameters.
- B. Provide devices as listed herein and as shown on Drawings.

1.02 ABBREVIATIONS AND REFERENCES

- A. NEC: National Electrical Code
- B. NEIS: National Electrical Installation Standards
- C. NEMA: National Electrical Manufacturers Association

1.03 SUBMITTALS

- A. General:
 1. Submit Product Data in sufficient detail to confirm compliance with requirements of this Section. Submit Product Data in one complete submittal package. Partial submittals are not acceptable.
- B. Product Data:
 1. Catalog cuts and product specifications for instrumentation specified.
- C. Operation and Maintenance (O&M) Data:
 1. Operating instructions and maintenance data for products for inclusion in O&M Manual.
 2. Manufacturer's written instructions for periodic test/calibration/cleaning for instrumentation and controls in service.
 3. Submit in accordance with Section 40 61 30.

1.04 DEFINITIONS

- A. The Rating column of instrument tables refers to the NEC hazardous environment rating the device is to be installed in.
1. CID2 – Class I Division 2 Group D
 2. NR – Not Rated

PART 2 – PRODUCTS

2.01 BALL FLOAT SWITCH

Location	Relative Elevation	Rating
9th Street Pump Station – Low Level	2.75 ft	CID2
9th Street Pump Station – High Level	11.50 ft	CID2

- A. Manufacturers:
1. Contegra FS 90.
 2. Evoqua Water Technologies 9G-EF.
- B. Requirements:
1. Float: 316 Stainless Steel.
 2. Provide sufficient length of PVC jacketed cable.
 3. For hazardous locations, provide intrinsically safe relays in corresponding control panel.
 4. Mounting Hardware: 316 Stainless Steel on vertical mounting pipe or stainless steel cable with anchor weight as indicated on Drawings.
 5. Switch: Non-Mercury tilt type 1A @ 150VAC/VDC non-inductive.

2.02 SUBMERSIBLE LEVEL SENSOR

Location	Range (ft)	Rating
9th Street Pump Station	0-16	CID2

- A. Manufacturers:
1. Endress and Hauser, Waterpilot FMX21.
 2. Keller America, Acculevel.
- B. Level transmitter consisting of variable capacitance, hydrostatic head-pressure sensing assembly enclosed in submersible Type 316 stainless steel housing with pressure sensing diaphragm and special cable containing breather tube and signal wiring.
- C. Provide intrinsically safe barriers when used in hazardous areas.
- D. Transducer:
1. Designed for continuous submergence.
 2. Low movement Teflon-faced diaphragm, 0.87 inch diameter.
 3. Oil-filled.
 4. Barometrically compensated
 5. Internal temperature compensation.
 6. Variable capacitance type internal sensing element.
 7. 2-wire, 4-20 mAdc HART.
 8. Span and off-set adjustable.
 9. Active transient protection.
 10. Long Term Stability: 0.1% of upper range value per year.
 11. Accuracy: $\pm 0.20\%$ of span.

- 12. Loop powered.
 - E. Cable Assembly:
 - 1. Positive seal where entering transducer housing.
 - 2. Contains breather tube.
 - 3. Provide sufficient length to accommodate installation.
 - F. Junction Box and Breather Assembly:
 - 1. Provide polycarbonate terminal box for submersible cable landing with filtered breather opening for atmospheric pressure compensation of breather tube.
 - 2. Desiccant systems not allowed.
- 2.03 INTRUSION PROXIMITY SWITCHES
- A. Manufacturers:
 - 1. GE Interlogix.
 - 2. Edwards Signaling.
 - B. Proximity switch for monitoring of building or control panel door position.
 - C. Solid State Hall Effect sensor with magnetic actuating bar.
 - D. Switch shall be industrial grade. Inductive, tubular or barrel type switches are not acceptable.
 - E. Provide dry contact suitable for connection to PLC input. Use switch manufacturer's recommended switching relay/amplifier as necessary to affect proper interface. Relay/amplifier shall be installed in PLC panel.

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Install and wire in accordance with equipment/instrument manufacturer's written instructions, approved submittals, applicable requirements of the NEC, NEIS, and recognized industry practices.
- B. Instrumentation transmitters, displays, and other indicators shall be configured to display information in the units given in this section and shall be orientated such that they are easily readable and accessible from operating locations.

3.02 IDENTIFICATION

- A. Provide equipment identification marker complete with equipment/device name and tag number. Markers shall be engraved plastic laminate, white with black core (letter color), and punched for mechanical fastening or stainless steel cable loop suspended from the instrument.

PANEL MOUNTED INSTRUMENTS

PART 1 – GENERAL

1.01 SUMMARY

- A. Section includes control panel mounted devices.

1.02 SUBMITTALS

- A. See Section 40 61 13 for submittal requirements.

PART 2 – PRODUCTS

2.01 PILOT DEVICES

- A. Manufacturer:
 - 1. Allen Bradley 800T/800H.
 - 2. Square D Class 9001, Type K.

- B. Construction:
 - 1. Heavy duty.
 - 2. Watertight.
 - 3. Oil-tight.
 - 4. Flush panel mounting.
 - 5. Size to mount in 30.5-mm diameter cutout.
 - 6. Match NEMA rating of device with the installed location environmental classification.
- C. Pushbuttons:
 - 1. Flush head unless specified elsewhere.
 - 2. Contact Blocks:
 - a. Double break silver contacts.
 - b. Ac Ratings: 7,200 va make, 720 va break.
 - c. Single pole, single throw.
 - d. Up to six tandem blocks.
 - 3. Momentary contact unless specified elsewhere.
 - 4. Non-illuminated.
 - 5. Legend plates, as required, for type of operation or as specified elsewhere.
- D. Selector Switches:
 - 1. Maintained position unless specified elsewhere.
 - 2. Contact Blocks:
 - a. Double break silver contacts.
 - b. Ac Ratings: 7,200va make, 720va break.
 - c. Single pole, double throw or double pole, single throw.
 - d. Up to six tandem blocks.
 - 3. Operators:
 - a. Number of positions as specified elsewhere.
 - b. Standard knob type unless specified elsewhere.
 - 4. Field mounted Local/Remote selector switches shall be provided with extra contact blocks for monitoring of "Remote" mode at the PLC.
 - 5. Legend plates as required for type of operation or specified elsewhere.
- E. Pilot Lights:
 - 1. LED Lamp.
 - 2. Transformer type.
 - 3. Bayonet, 6Vac bulb.
 - 4. Colored lens as specified elsewhere.
 - 5. Interchangeable lenses.
 - 6. Transformer rated for 120Vac.
 - 7. Push to test.
 - 8. Legend plates as specified elsewhere.

2.02 MAGNETIC MOTOR CONTROLLERS

- A. Manufacturer:
 - 1. Rockwell Automation.
 - 2. Eaton Corporation.
 - 3. Schneider Electric.
- B. Description: NEMA ICS 3, Class A, full voltage, non-reversing, across-the-line controller.
- C. Control Circuit: 120 Volt; obtained from integral control power transformer, unless otherwise indicated. Include control power transformer with adequate capacity to operate connected pilot, indicating and control devices, plus 100% spare capacity.

- D. Electronic solid state type with inverse-time-current characteristic, phase loss and phase unbalance protection with normally closed overload trip contact for monitoring.
- 2.03 MOTOR STARTER CONTROL RELAYS
- A. Manufacturer:
1. Square D.
 2. Cutler-Hammer.
- B. Construction:
1. Industrial type.
 2. 300Vac rated.
 3. Ac operation.
 4. Used for operation of large motor starter coils or other 120Vac loads whose current requirements (continuous or inrush) exceed capacity of control relays listed below.
- C. Operating data:
1. Pickup time: 11 ms maximum.
 2. Dropout time: 6 ms maximum.
- D. Coil:
1. Molded construction.
 2. 120Vac, 60Hz.
 3. Continuous rated.
 4. 155va inrush, maximum.
 5. 22va sealed, maximum.
- E. Contacts:
1. Double break.
 2. Silver alloy.
 3. Convertible.
 4. Color-coded to indicate status.
 5. 60 amp make, 6 amp break (120Vac inductive).
- F. DIN rail-mounting capability.
- G. Accessories:
1. Add-on pole attachment.
 - a. 4 NO and 4 NC contacts.
 - b. Add-on to 0 to 4-pole relay.
 2. Latch attachment.
- 2.04 CONTROL RELAYS
- A. Manufacturer:
1. Allen Bradley
 2. Potter and Brumfield.
 3. Idec.
 4. Magnecraft.
- B. Operating Data:
1. Pickup Time: 13 ms maximum.
 2. Dropout Time: 10 ms maximum.
 3. Operating Temperature: -45°F to 150°F.
- C. ac Coil:
1. 120Vac.
 2. Continuous rated.
 3. 3.5va inrush maximum.
 4. 1.2va sealed, maximum.
 5. 50-60 Hz.
 6. Light to indicate energization.

- 7. Minimum Dropout Voltage: 10% of coil rated voltage.
- D. dc Coil:
 - 1. 24Vdc.
 - 2. Continuous rated.
 - 3. Light to indicate energization.
 - 4. Minimum Coil Resistance, 24Vdc: 450 Ω .
- E. Contacts:
 - 1. Gold flashed fine silver, gold diffused for 1 amp or less resistive load.
 - 2. Silver cadmium oxide.
 - 3. 3 form C.
 - 4. 300Vac.
 - 5. 10 amp make, 1.5 amp break, (inductive).
- F. Construction:
 - 1. Rated at 10 million operations.
 - 2. 11 pin, square socket.
 - 3. DIN rail mountable.
 - 4. Enclosed and protected by polycarbonate cover.
 - 5. Visible indication of energized coil.
 - 6. Provide relay-retaining clips.
- 2.05 TERMINAL BLOCKS
 - A. Manufacturer:
 - 1. Phoenix Contact.
 - 2. Weidmuller.
 - B. Construction:
 - 1. 300 v rating for 120 v circuits and below, 600 v rating for 480 v circuits.
 - 2. Clamping screw type.
 - 3. Isolating end caps for each terminal.
 - 4. Identification on both terminals.
 - 5. Clip-mounted on DIN rail.
 - 6. Accepts AWG 12 to 22.
 - 7. 20 amp rate feed-through terminals
 - 8. Switched Terminals:
 - a. Knife disconnect with test sockets.
 - b. 10 Amp rating.
 - 9. Fused Terminals:
 - a. Hinged fuse removal/disconnect.
 - b. 10 Amp rating.
 - c. Include blown fuse indication.
- 2.06 DC POWER SUPPLIES
 - A. Manufacturer:
 - 1. Phoenix Contact
 - 2. Sola/Hevi-Duty
 - B. General:
 - 1. Power supply shall be fully enclosed, and provide screw terminations. All wiring points and plug connections shall be "touch safe" with no live voltages that can make contact with a misplaced finger in accordance with IEC 529. Housing shall be at IP20 or equal minimum.
 - 2. Power Supplies shall have an efficiency of at least 80% with high efficiency models (~90%) available
 - 3. The power shall have an MTBF (Mean Time Between Failures) greater than 500,000 hours according to IEC 1709.

4. The power supply shall be able to withstand shock of 30G in all space directions according to IEC 68-2-27 and vibration up to 2.3G 90 min. (<15hz, amplitude = +/-2.5mm/15-150hz) according to IEC 68-2-6.
5. Power supplies shall be UL-508A listed to allow the use of the power supply at full rated output amperage with no "de-rating".
- C. Mounting:
 1. All power supplies shall have integral metal mounting foot to attach to 35mm DIN-rail conforming to DIN EN50022.
- D. Wire Connections:
 1. Attach wires to the power supplies by means of a cable-clamping terminal block activated by a screw. Connections shall be gas-tight, and the terminal block shall be fabricated with non-ferrous, non-corrosive materials.
 2. Wire connection for currents less than 20A shall use pluggable terminals on both input and output ends.
 3. Pluggable terminals shall accept wire sizes 24 through 14 AWG.
- E. Equipment:
 1. Nominal current rating to be based on an operating temperature of 60°C or higher
 2. Power supplies shall have a visible "DC Power OK" indicator. This indicator will flash when the output drops below 10% of the adjusted output voltage.
 3. Ambient temperature range for operation shall be at least -25°C to +70°C
 4. Residual ripple shall not exceed 100 mV peak to peak at nominal current values
 5. Integral "fine" surge suppression shall be incorporated into the power supply
 6. Power supplies shall conform to CE electromagnetic compatibility as described in EN61000-6-2 and EN 50081-2.
 7. Power supplies shall have means of limiting DC current in case of short circuit or an overload and shall automatically reset themselves when the fault is corrected.
 8. Power supplies when wired in parallel will not require external circuitry.
 9. Power supplies shall have a voltage monitoring relay contact and signaling output.
 10. Input must auto-range between 85 to 264VAC and 90 to 350VDC for 1 phase power supplies with no manual intervention.
 11. Input must auto-range between 320 to 575VAC and 450 to 800VDC for 3 phase power supplies with no manual intervention.
 12. Power supplies shall have a power factor of at least 0.6, with higher power factor models available as described by EN61000-3-2.
- 2.07 ELECTRONIC CURRENT ISOLATOR
 - A. Manufacturer:
 1. Phoenix Contact Model MCR Series.
 2. PR Electronics.
 - B. Solid state instrument to electrically isolate one instrument loop from another instrument loop. Converter to accept 4-20 mAdc input signal and provide equal but isolated and power-booster output.
 - C. Construction:
 1. Mounting: DIN Rail.
 2. Temperature compensated, calibration-free.
 3. Input: 4-20 mAdc into 50 ohms.
 4. Output: 4-20 mAdc into output load up to 500 ohms.
 5. Isolation: Common mode up to 700Vac between input and output.
 6. Accuracy: 0.5% of span.
 7. Provide power supply specific to isolator.
- 2.08 SURGE PROTECTORS
 - A. Manufacturer:

1. Islatrol - IE-100 series
 2. SOLA STFE Elite Series.
 - B. High frequency noise filter/surge protector to protect control panel incoming power supply.
 - C. Wire to protect specified microprocessor based process control system devices.
 - D. Input power:
 1. 120 or 240Vac, model dependant.
 2. 47-63 Hz.
 - E. Peak surge current: Minimum 10,000 amp line-neutral, line to ground, and neutral to ground.
 - F. Frequency response:
 1. Normal mode: 90 dB max, 100 kHz to 50 MHz.
 2. Common mode: 60 dB max, 5 MHz to 50 MHz.
 - G. Response time:
 1. < 0.5 ns normal mode.
 2. <5 ns common mode.
 - H. Transient protection per IEEE C62.41:
 1. Category A Ringwave (6kV, 200A, 100 MHz): < 60 V peak.
 2. Category B Ringwave (6kV, 500A, 100 MHz): < 100 V peak.
 - I. LED status indicator.
 - J. Form C contact for remote status indication.
- 2.09 UNINTERRUPTIBLE POWER SUPPLY
- A. Manufacturer:
 1. Emerson
 2. Alpha
 3. Eaton
 4. APC
 5. ABB
 6. Sola
 - B. Features:
 1. Input power: 120Vac utility grade.
 2. UPS shall power all control panel devices, external instruments, and equipment as shown on Drawings.
 3. Size UPS at 125% of connected electrical load (minimum).
 4. Minimum UPS size shall be 600VA.
 5. Installed in control panel (DIN Rail or Tower).
 6. Provide true on-line non switching UPS.
 7. Double power conversion on-line operation including rectifier and inverter, constantly conditioned AC output.
 8. UL Listed.
 9. Provide bypass contactor or other means to automatically bypass UPS allowing operation of system controls in event of UPS failure. Device contacts shall be rated for inductive loads and shall meet or exceed current protection of circuit.
 10. Each system shall consist of a static dc to ac sine wave inverter, a battery charger, sealed batteries, a monitor and transfer switch, and accessories as listed below.
 11. Each system shall operate on a 120-volt, 60-Hz ac branch circuit. The input ac circuit shall supply energy to the battery charger which shall supply energy to the inverter as well as to the battery to maintain its charge. The output of the inverter shall supply energy to the load. If the input ac circuit is interrupted, the inverter shall continue to supply energy to the load without interruption, drawing power from the battery. If the input ac circuit is restored prior to discharge of the battery,

the charger shall resume the supply of energy to the inverter and shall restore the battery to full charge. In the event of malfunction of the battery charger, battery or inverter that results in interruption of the output from the inverter, the monitor shall detect this condition and shall automatically transfer the load to the system's ac input circuit within 25 milliseconds. After the malfunction is corrected, the load shall be retransferred to the inverter manually.

12. System output voltage shall be regulated within plus or minus 5 percent of 120 volts and frequency stability shall be plus or minus 1/2 percent of 60-Hz. The output characteristic shall be sinusoidal with not more than 5 percent total harmonic distortion at full load with input ac circuit at 120 volts. For a 20 percent instantaneous load change, voltage overshoot or undershoot shall be not more than plus or minus 10 percent. For a 10 to 90 percent load change, recovery time shall be not longer than 100 milliseconds.
13. Input protection shall be provided by a panel-mount circuit breaker. Each inverter shall be the load current-limiting type and each shall have overload and short circuit protection provided by a circuit breaker. Efficiency shall be 75 percent for the inverter and 85 percent for the battery charger minimum.
14. UPS shall supply power to panel devices, field instruments, and other low voltage control devices as specified and as shown on Drawings.
15. UPS shall have enough capacity to power connected devices for a period of 15 minutes after the utility power has failed. Provide with extended battery module(s) to meet this requirement. Additional batteries shall be contained within panel enclosure unless approved by Owner and Engineer.
16. UPS shall include a status signal output for equipment malfunction/failure.

2.10 INTRINSICALLY SAFE BARRIERS

- A. Manufacturer:
 1. PR Electronics.
 2. No substitutes permitted.
- B. Intrinsically safe barrier located in safe area, allow intrinsically safe interface to devices located in Class I, Division 1 or 2, Group C or D hazardous (classified) locations per National Electrical Code ANSI/NFPA 70 (NEC).
- C. Non-Zener Diode mode of protection
- D. UL and CE listed, FM approved.
- E. Operating temperature range -20 to 60 degrees F.
- F. Supply voltage: 20–35 VDC.
- G. DIN rail mounted.
- H. Isolation: 250 V rms between safe and hazardous area terminals.
- I. LED indication of operation status and malfunction.
- J. Discrete Input
 1. Suitable for monitoring of switch closure, NAMUR sensors.
 2. Capable of line fault detection when specified, provide series and parallel resistors at switch location when line fault detection specified.
 3. Safe area contact ratings: 125 VAC, 0.5 A, resistive.
- K. Analog Input
 1. Suitable for monitoring of 4-20 mAdc signals.
 2. Safe area output: Isolated 4-20 mAdc, active or passive dependant on application.

2.11 UTP PATCH CORDS FOR EQUIPMENT ENCLOSURES

- A. Manufacturer:
 1. Lucent Technologies.
 2. Panduit.
- B. Provide Category 6 Modular Patch Cords as follows:

1. Power sum rated.
2. Patch cords shall not exceed 3 feet in length unless specifically required for application.
3. Conform to the requirements of EIA/TIA 568B Commercial Building Telecommunications Cabling Standard, Horizontal Cabling Section, and UL $\square$ LAN Certification and Follow-up Program.
4. Equipped with molded 8 pin modular connector (RJ45, 8x8) on each end and conform to the length(s) specified on the detailed drawing.
5. Round, and 24-AWG copper, stranded conductors, tightly twisted into individual pairs.
6. Built-in exclusion features to prevent accidental polarity reversals and split pairs.
7. UL $\square$ Verified for EIA/TIA 568B Electrical Performance.
8. UL $\square$ and c (UL $\square$) Listed for Fire Safety.
9. ISO 9001 Certified Manufacturer.
10. Austel Approved.
11. FCC Compliant.

2.12 OPERATOR INTERFACE UNIT (OIU)

- A. Manufacturer:
 1. Rockwell Automation, PanelView Plus 7 Performance
- B. General:
 1. Microprocessor based graphical operator interface.
 2. Enclosure Rating: NEMA 12, 13 and 4X, (IP66).
 3. 0-50 $\square$ C operating range.
 4. Touch style.
 5. PLC peer to peer network, Ethernet or direct serial interface.
 6. System Memory: 512MB RAM, 512MB Storage.
 7. User Memory: 80MB nonvolatile.
 8. Battery Backup.
 9. Input Voltage: 100-240Vac.
- C. Display
 1. Size: 10 inch diagonal.
 2. Resolution: 1280 X 1024 SXGA 18-bit color graphics.
 3. Aspect Ratio: 5:4.
 4. Active matrix Thin Film Transistor.
 5. Analog resistive screen.
- D. Software:
 1. Rockwell Automation FactoryTalk View Machine Edition.
- E. Additional:
 1. Provide 2GB SD Card (1784-SD2).
 2. Provide clear polyester (0.007") anti-glare overlay (2711P-RGT19P).

2.13 PROGRAMMABLE LOGIC CONTROLLER (PLC)

- A. Manufacturer:
 1. Allen-Bradley CompactLogix 5370 L1 (1769-L19ER-BB1B)
- B. Features
 1. Built-in 24V DC power supply.
 2. 1 MB User Memory
 3. Two embedded 10/100 Mbps Ethernet ports.
 4. One embedded USB port.
 5. 8 Ethernet/IP nodes supported.
 6. 1 GB non-volatile memory module installed (1784-SD1).
 7. Embedded I/O:

- a. 16 sinking/sourcing 24V DC digital inputs.
- b. 16 sourcing 24V DC digital outputs.
- 8. 8 module expansion capability for additional I/O:
 - a. Analog Input:
 - 1) 4-channel
 - 2) Current/voltage
 - 3) 1769-IF4 or IF4I
- 9. UL Listed Industrial Control Equipment.
- 10. Programming: Rockwell Studio 5000

PART 3 – EXECUTION

3.01 INSTALLATION

- A. Install and wire in accordance with equipment/instrument manufacturer's written instructions, approved submittals, applicable requirements of the NEC, NEIS, and recognized industry practices.
- B. Analog I/O shall use specialty field terminal blocks specifically designed for 4-20mA signal wiring.
- C. PLC-specific requirements:
 - 1. Each installation shall monitor raw incoming power (prior to a UPS) to identify site power failures. This power failure shall be monitored by a normally closed (utility power available) discrete input.
 - 2. Provide orderly shutdown on power failure, saving register contents with automatic restart on power restoration.
 - 3. Each input shall be individually fused except when a group of inputs serve a common device or common function such as a remote control station for a piece of equipment.

STATUS OF UTILITIES TO BE ADJUSTED

NO UTILITIES TO BE ADJUSTED

The above represents the best information of the Department and is only included for the convenience of the bidder. The applicable provisions of Sections 102, 103, and Articles 105.07 and 107.20 of the Standard Specifications for Road and Bridge Construction shall apply.

If any utility adjustment or removal has not been completed when required by the Contractor's operation, the Contractor should notify the Engineer in writing. A request for an extension of time will be considered to the extent the Contractor's operations were affected.

CEMENT, FINELY DIVIDED MINERALS, ADMIXTURES; CONCRETE, AND MORTAR (BDE)

Effective: January 1, 2025

Revise the first paragraph of Article 285.05 of the Standard Specifications to read:

“285.05 Fabric Formed Concrete Revetment Mat. The grout shall consist of a mixture of cement, fine aggregate, and water so proportioned and mixed as to provide a pumpable slurry. Fly ash or ground granulated blast furnace (GGBF) slag, and concrete admixtures may be used at the option of the Contractor. The grout shall have an air content of not less than 6.0 percent nor more than 9.0 percent of the volume of the grout. The mix shall obtain a compressive strength of 2500 psi (17,000 kPa) at 28 days according to Article 1020.09.”

Revise Article 302.02 of the Standard Specifications to read:

“302.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Cement	1001
(b) Water	1002
(c) Hydrated Lime	1012.01
(d) By-Product, Hydrated Lime	1012.02
(e) By-Product, Non-Hydrated Lime	1012.03
(f) Lime Slurry	1012.04
(g) Fly Ash	1010
(h) Soil for Soil Modification (Note 1)	1009.01
(i) Bituminous Materials (Note 2)	1032

Note 1. This soil requirement only applies when modifying with lime (slurry or dry).

Note 2. The bituminous materials used for curing shall be emulsified asphalt RS-2, CRS-2, HFE 90, or HFE 150; rapid curing liquid asphalt RC-70; or medium curing liquid asphalt MC-70 or MC-250.”

Revise Article 312.07(c) of the Standard Specifications to read:

“(c) Cement1001”

Add Article 312.07(i) of the Standard Specifications to read:

“(i) Ground Granulated Blast Furnace (GGBF) Slag1010”

Revise the first paragraph of Article 312.09 of the Standard Specifications to read:

“312.09 Proportioning and Mix Design. At least 60 days prior to start of placing CAM II, the Contractor shall submit samples of materials to be used in the work for proportioning and testing. The mixture shall contain a minimum of 200 lb (120 kg) of cement per cubic yard (cubic meter). Cement may be replaced with fly ash or ground granulated blast furnace (GGBF) slag according to Article 1020.05(c)(1) or 1020.05(c)(2), respectively, however the minimum cement content in the mixture shall be 170 lbs/cu yd (101 kg/cu m). Blends of coarse and fine aggregates will be

permitted, provided the volume of fine aggregate does not exceed the volume of coarse aggregate. The Engineer will determine the proportions of materials for the mixture according to the "Portland Cement Concrete Level III Technician Course" manual. However, the Contractor may substitute their own mix design. Article 1020.05(a) shall apply, and a Level III PCC Technician shall develop the mix design."

Revise Article 352.02 of the Standard Specifications to read:

"352.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Cement (Note 1)	1001
(b) Soil for Soil-Cement Base Course	1009.03
(c) Water	1002
(d) Bituminous Materials (Note 2)	1032

Note 1. Bulk cement may be used for the traveling mixing plant method if the equipment for handling, weighing, and spreading the cement is approved by the Engineer.

Note 2. The bituminous materials used for curing shall be emulsified asphalt RS-2, CRS-2, HFE 90, or HFE 150; rapid curing liquid asphalt RC-70; or medium curing liquid asphalt MC-70 or MC-250."

Revise Article 404.02 of the Standard Specifications to read:

"404.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Cement	1001
(b) Water	1002
(c) Fine Aggregate	1003.08
(d) Bituminous Material (Tack Coat)	1032.06
(e) Emulsified Asphalts (Note 1) (Note 2)	1032.06
(f) Fiber Modified Joint Sealer	1050.05
(g) Additives (Note 3)	

Note 1. When used for slurry seal, the emulsified asphalt shall be CQS-1h according to Article 1032.06(b).

Note 2. When used for micro-surfacing, the emulsified asphalt shall be CQS-1hP according to Article 1032.06(e).

Note 3. Additives may be added to the emulsion mix or any of the component materials to provide the control of the quick-traffic properties. They shall be included as part of the mix design and be compatible with the other components of the mix.

Revise the last sentence of the fourth paragraph of Article 404.08 of the Standard Specifications to read:

"When approved by the Engineer, the sealant may be dusted with fine sand, cement, or mineral filler to prevent tracking."

Revise Note 2 of Article 516.02 of the Standard Specifications to read:

“Note 2. The sand-cement grout mix shall be according to Section 1020 and shall be a 1:1 blend of sand and cement comprised of a Type I, IL, or II cement at 185 lb/cu yd (110 kg/cu m). The maximum water cement ratio shall be sufficient to provide a flowable mixture with a typical slump of 10 in. (250 mm).”

Revise Note 2 of Article 543.02 of the Standard Specifications to read:

“Note 2. The grout mixture shall be 6.50 hundredweight/cu yd (385 kg/cu m) of cement plus fine aggregate and water. Fly ash or ground granulated blast furnace (GGBF) slag may replace a maximum of 5.25 hundredweight/cu yd (310 kg/cu m) of the cement. The water/cement ratio, according to Article 1020.06, shall not exceed 0.60. An air-entraining admixture shall be used to produce an air content, according to Article 1020.08, of not less than 6.0 percent nor more than 9.0 percent of the volume of the grout. The Contractor shall have the option to use a water-reducing or high range water-reducing admixture.”

Revise Article 583.01 of the Standard Specifications to read:

“583.01 Description. This work shall consist of placing cement mortar along precast, prestressed concrete bridge deck beams as required for fairing out any unevenness between adjacent deck beams prior to placing of waterproofing membrane and surfacing.”

Revise Article 583.02(a) of the Standard Specifications to read:

“(a) Cement1001”

Revise the first paragraph of Article 583.03 of the Standard Specifications to read:

“ 583.03 General. This work shall only be performed when the air temperature is 45 °F (7 °C) and rising. The mixture for cement mortar shall consist of three parts sand to one part cement by volume. The amount of water shall be no more than that necessary to produce a workable, plastic mortar.”

Revise Note 2/ in Article 1003.01(b) of the Standard Specifications to read:

“2/ Applies only to sand. Sand exceeding the colorimetric test standard of 11 (Illinois Modified AASHTO T 21) will be checked for mortar making properties according to Illinois Modified ASTM C 87 and shall develop a compressive strength at the age of 14 days when using Type I, IL, or II cement of not less than 95 percent of the comparable standard.

Revise the second sentence of Article 1003.02(e)(1) of the Standard Specifications to read:

“The test will be performed with Type I, IL, or II portland cement having a total equivalent alkali content ($\text{Na}_2\text{O} + 0.658\text{K}_2\text{O}$) of 0.90 percent or greater.”

Revise the first sentence of the second paragraph of Article 1003.02(e)(3) of the Standard Specifications to read:

“The ASTM C 1293 test shall be performed with Type I, IL, or II portland cement having a total equivalent alkali content ($\text{Na}_2\text{O} + 0.658\text{K}_2\text{O}$) of 0.80 percent or greater.”

Revise the second sentence of Article 1004.02(g)(1) of the Standard Specifications to read:

“The test will be performed with Type I, IL, or II portland cement having a total equivalent alkali content ($\text{Na}_2\text{O} + 0.658\text{K}_2\text{O}$) of 0.90 percent or greater.”

Revise Article 1017.01 of the Standard Specifications to read:

“1017.01 Requirements. The mortar shall be high-strength according to ASTM C 387 and shall have a minimum 80.0 percent relative dynamic modulus of elasticity when tested by the Department according to Illinois Modified AASHTO T 161 or AASHTO T 161 when tested by an independent lab. The high-strength mortar shall have a water-soluble chloride ion content of less than 0.40 lb/cu yd (0.24 kg/cu m). The test shall be performed according to ASTM C 1218, and the high-strength mortar shall have an age of 28 to 42 days at the time of test. The ASTM C 1218 test shall be performed by an independent lab a minimum of once every five years, and the test results shall be provided to the Department. Mixing of the high-strength mortar shall be according to the manufacturer’s specifications. The Department will maintain a qualified product list.”

Revise the fourth sentence of Article 1018.01 of the Standard Specifications to read:

“The ASTM C 1218 test shall be performed by an independent lab a minimum of once every five years, and the test results shall be provided to the Department.”

Revise Article 1019.02 of the Standard Specifications to read:

“1019.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Cement	1001
(b) Water	1002
(c) Fine Aggregate for Controlled Low-Strength Material (CLSM)	1003.06
(d) Fly Ash	1010
(e) Ground Granulated Blast Furnace (GGBF) Slag.....	1010
(f) Admixtures (Note 1)	

Note 1. The air-entraining admixture may be in powder or liquid form. Prior to approval, a CLSM air-entraining admixture will be evaluated by the Department. The admixture shall be able to meet the air content requirements of Mix 2. The Department will maintain a qualified product list.”

Revise Article 1019.05 of the Standard Specifications to read:

“1019.05 Department Mix Design. The Department mix design shall be Mix 1, 2, or 3 and shall be proportioned to yield approximately one cubic yard (cubic meter).

VARIOUS ROUTES
SECTION DIST 8 PS 2025-1
MADISON, ST. CLAIR, AND MARION COUNTIES
CONTRACT NO. 76U37

Mix 1	
Cement	50 lb (30 kg)
Fly Ash – Class C or F, and/or GGBF Slag	125 lb (74 kg)
Fine Aggregate – Saturated Surface Dry	2900 lb (1720 kg)
Water	50-65 gal (248-322 L)
Air Content	No air is entrained

Mix 2	
Cement	125 lb (74 kg)
Fine Aggregate – Saturated Surface Dry	2500 lb (1483 kg)
Water	35-50 gal (173-248 L)
Air Content	15-25 %

Mix 3	
Cement	40 lb (24 kg)
Fly Ash – Class C or F, and/or GGBF Slag	125 lb (74 kg)
Fine Aggregate – Saturated Surface Dry	2500 lb (1483 kg)
Water	35-50 gal (179-248 L)
Air Content	15-25 %

Revise Article 1020.04, Table 1, Note (8) of the Standard Specifications to read:

“(8) In addition to the Type III portland cement, 100 lb/cu yd of ground granulated blast-furnace slag and 50 lb/cu yd of microsilica (silica fume) shall be used. For an air temperature greater than 85 °F, the Type III portland cement may be replaced with Type I, IL, or II portland cement.”

Revise Article 1020.04, Table 1 (Metric), Note (8) of the Standard Specifications to read:

“(8) In addition to the Type III portland cement, 60 kg/cu m of ground granulated blast-furnace slag and 30 kg/cu m of microsilica (silica fume) shall be used. For an air temperature greater than 30 °C, the Type III portland cement may be replaced with Type I, IL, or II portland cement.”

Revise the second paragraph of Article 1020.05(a) of the Standard Specifications to read:

“For a mix design using a portland-pozzolan cement, portland blast-furnace slag cement, portland-limestone cement, or replacing portland cement with finely divided minerals per Articles 1020.05(c) and 1020.05(d), the Contractor may submit a mix design with a minimum portland cement content less than 400 lbs/cu yd (237 kg/cu m), but not less than 375 lbs/cu yd (222 kg/cu m), if the mix design is shown to have a minimum relative dynamic modulus of elasticity of 80 percent determined according to AASHTO T 161. Testing shall be performed by an independent laboratory accredited by AASHTO re:source for Portland Cement Concrete.”

Revise the first sentence of the first paragraph of Article 1020.05(b) of the Standard Specifications to read:

“Corrosion inhibitors and concrete admixtures shall be according to the qualified product lists.”

Delete the fourth and fifth sentences of the second paragraph of Article 1020.05(b) of the Standard Specifications.

Revise the third sentence of the second paragraph of Article 1020.05(b)(5) of the Standard Specifications to read:

“The qualified product lists of concrete admixtures shall not apply.”

Revise second paragraph of Article 1020.05(b)(10) of the Standard Specifications to read:

“When calcium nitrite is used, it shall be added at the rate of 4 gal/cu yd (20 L/cu m) and shall be added to the mix immediately after all compatible admixtures have been introduced to the batch. Other corrosion inhibitors shall be added per the manufacturer’s specifications.”

Delete the third paragraph of Article 1020.05(b)(10) of the Standard Specifications.

Revise Article 1020.15(b)(1)c. of the Standard Specifications to read:

“c. The minimum portland cement content in the mixture shall be 375 lbs/cu yd (222 kg/cu m). When the total of organic processing additions, inorganic processing additions, and limestone addition exceed 5.0 percent in the cement, the minimum portland cement content in the mixture shall be 400 lbs/cu yd (237 kg/cu m). For a drilled shaft, foundation, footing, or substructure, the minimum portland cement may be reduced to as low as 330 lbs/cu yd (196 kg/cu m) if the concrete has adequate freeze/thaw durability. The Contractor shall provide freeze/thaw test results according to AASHTO T 161, and the relative dynamic modulus of elasticity of the mix design shall be a minimum of 80 percent. Testing shall be performed by an independent laboratory accredited by AASHTO re:source for Portland Cement Concrete. Freeze/thaw testing will not be required for concrete that will not be exposed to freezing and thawing conditions as determined by the Engineer.”

Revise Article 1021.01 of the Standard Specifications to read:

“1021.01 General. Admixtures shall be furnished in liquid or powder form ready for use. The admixtures shall be delivered in the manufacturer’s original containers, bulk tank trucks or such containers or tanks as are acceptable to the Engineer. Delivery shall be accompanied by a ticket which clearly identifies the manufacturer, the date of manufacture, and trade name of the material. Containers shall be readily identifiable as to manufacturer, the date of manufacture, and trade name of the material they contain.

Concrete admixtures shall be on one of the Department’s qualified product lists. Unless otherwise noted, admixtures shall have successfully completed and remain current with the AASHTO Product Eval and Audit Concrete Admixture (CADD) testing program. For admixture submittals to the Department; the product brand name, manufacturer name, admixture type or types, an electronic link to the product’s technical data sheet, and the NTPEP testing number which contains an electronic link to all test data shall be provided. In addition, a letter shall be

submitted certifying that no changes have been made in the formulation of the material since the most current round of tests conducted by AASHTO Product Eval and Audit. After 28 days of testing by AASHTO Product Eval and Audit, air-entraining admixtures may be provisionally approved and used on Departmental projects. For all other admixtures, unless otherwise noted, the time period after which provisionally approved status may be earned is 6 months.

The manufacturer shall include the following in the submittal to the AASHTO Product Eval and Audit CADD testing program: the manufacturing range for specific gravity, the midpoint and manufacturing range for residue by oven drying, and manufacturing range of pH. The submittal shall also include an infrared spectrophotometer trace no more than five years old.

For air-entraining admixtures according to Article 1021.02, the specific gravity allowable manufacturing range established by the manufacturer shall be according to AASHTO M 194. For residue by oven drying and pH, the allowable manufacturing range and test methods shall be according to AASHTO M 194.

For admixtures according to Articles 1021.03, 1021.04, 1021.05, 1021.06, 1021.07, and 1021.08, the pH allowable manufacturing range established by the manufacturer shall be according to ASTM E 70. For specific gravity and residue by oven drying, the allowable manufacturing range and test methods shall be according to AASHTO M 194.

All admixtures, except chloride-based accelerators, shall contain a maximum of 0.3 percent chloride by weight (mass) as determined by an appropriate test method. To verify the test result, the Department will use Illinois Modified AASHTO T 260, Procedure A, Method 1.

Prior to final approval of an admixture, the Engineer reserves the right to request a sample for testing. The test and reference concrete mixtures tested by the Engineer will contain a cement content of 5.65 cwt/cu yd (335 kg/cu m). For freeze-thaw testing, the Department will perform the test according to Illinois Modified AASHTO T 161. The flexural strength test will be performed according to AASHTO T 177. If the Engineer decides to test the admixture, the manufacturer shall submit AASHTO T 197 water content and set time test results on the standard cement used by the Department. The manufacturer may select their lab or an independent lab to perform this testing. The laboratory is not required to be accredited by AASHTO.

Random field samples may be taken by the Department to verify an admixture meets specification. A split sample will be provided to the manufacturer if requested. Admixtures that do not meet specification requirements or an allowable manufacturing range established by the manufacturer shall be replaced with new material.”

Revise Article 1021.03 of the Standard Specifications to read:

“1021.03 Retarding and Water-Reducing Admixtures. The admixture shall be according to the following.

- (a) Retarding admixtures shall be according to AASHTO M 194, Type B (retarding) or Type D (water-reducing and retarding).
- (b) Water-reducing admixtures shall be according to AASHTO M 194, Type A.
- (c) High range water-reducing admixtures shall be according to AASHTO M 194, Type F (high range water-reducing) or Type G (high range water-reducing and retarding).”

Revise Article 1021.05 of the Standard Specifications to read:

“1021.05 Self-Consolidating Admixtures. Self-consolidating admixture systems shall consist of either a high range water-reducing admixture only or a high range water-reducing admixture combined with a separate viscosity modifying admixture. The one or two component admixture system shall be capable of producing a concrete that can flow around reinforcement and consolidate under its own weight without additional effort and without segregation.

High range water-reducing admixtures shall be according to AASHTO M 194, Type F.

Viscosity modifying admixtures shall be according to AASHTO M 194, Type S (specific performance).”

Revise Article 1021.06 of the Standard Specifications to read:

“1021.06 Rheology-Controlling Admixture. Rheology-controlling admixtures shall be capable of producing a concrete mixture with a lower yield stress that will consolidate easier for slipform applications used by the Contractor. Rheology-controlling admixtures shall be according to AASHTO M 194, Type S (specific performance).”

Revise Article 1021.07 of the Standard Specifications to read:

“1021.07 Corrosion Inhibitor. The corrosion inhibitor shall be according to one of the following.

(a) Calcium Nitrite. Corrosion inhibitors shall contain a minimum 30 percent calcium nitrite by weight (mass) of solution and shall comply with either the requirements of AASHTO M 194, Type C (accelerating) or the requirements of ASTM C 1582. The corrosion inhibiting performance requirements of ASTM C 1582 shall not apply.

(b) Other Materials. The corrosion inhibitor shall be according to ASTM C 1582.

For submittals requiring testing according to ASTM M 194, Type C (accelerating), the admixture shall meet the requirements of the AASHTO Product Eval and Audit CADD testing program according to Article 1021.01.

For submittals requiring testing according to ASTM C 1582, a report prepared by an independent laboratory accredited by AASHTO re:source for portland cement concrete shall be provided. The report shall show the results of physical tests conducted no more than five years prior to the time of submittal, according to applicable specifications. However, ASTM G 109 test information specified in ASTM C 1582 is not required to be from an independent accredited lab. All other information in ASTM C 1582 shall be from an independent accredited lab. Test data and other information required to be submitted to AASHTO Product Eval and Audit according to Article 1021.01, shall instead be submitted directly to the Department.”

Add Article 1021.08 of the Standard Specifications as follows:

“1021.08 Other Specific Performance Admixtures. Other specific performance admixtures shall, at a minimum, be according to AASHTO M 194, Type S (specific performance). The

Department also reserves the right to require other testing, as determined by the Engineer, to show evidence of specific performance characteristics.

Initial testing according to AASHTO M 194 may be conducted under the AASHTO Product Eval and Audit CADD testing program according to Article 1021.01, or by an independent laboratory accredited by AASHTO re:source for Portland Cement Concrete. In either case, test data and other information required to be submitted to AASHTO Product Eval and Audit according to Article 1021.01, shall also be submitted directly to the Department. The independent accredited lab report shall show the results of physical tests conducted no more than five years prior to the time of submittal, according to applicable specifications.”

Revise Article 1024.01 of the Standard Specifications to read:

“1024.01 Requirements for Grout. The grout shall be proportioned by dry volume, thoroughly mixed, and shall have a minimum temperature of 50 °F (10 °C). Water shall not exceed the minimum needed for placement and finishing.

Materials for the grout shall be according to the following.

Item	Article/Section
(a) Cement	1001
(b) Water	1002
(c) Fine Aggregate	1003.02
(d) Fly Ash	1010
(e) Ground Granulated Blast Furnace (GGBF) Slag.....	1010
(f) Concrete Admixtures	1021”

Revise Note 1 of Article 1024.02 of the Standard Specifications to read:

“Note 1. Nonshrink grout shall be according to Illinois Modified ASTM C 1107.

The nonshrink grout shall have a water-soluble chloride ion content of less than 0.40 lb/cu yd (0.24 kg/cu m). The test shall be performed according to ASTM C 1218, and the grout shall have an age of 28 to 42 days at the time of test. The ASTM C 1218 test shall be performed by an independent lab a minimum of once every five years, and the test results shall be provided to the Department. Mixing of the nonshrink grout shall be according to the manufacturer’s specifications. The Department will maintain a qualified product list.”

Revise Article 1029.02 of the Standard Specifications to read:

“ 1029.02 Materials. Materials shall be according to the following.

Item	Article/Section
(a) Cement.....	1001
(b) Fly Ash	1010
(c) Ground Granulated Blast Furnace (GGBF) Slag	1010
(d) Water.....	1002
(e) Fine Aggregate.....	1003
(f) Concrete Admixtures	1021
(g) Foaming Agent (Note 1)	

Note 1. The manufacturer shall submit infrared spectrophotometer trace and test results indicating the foaming agent meets the requirements of ASTM C 869 in order to be on the Department's qualified product list. Submitted data/results shall not be more than five years old."

Revise the second paragraph of Article 1103.03(a)(4) the Standard Specifications to read:

"The dispenser system shall provide a visual indication that the liquid admixture is actually entering the batch, such as via a transparent or translucent section of tubing or by independent check with an integrated secondary metering device. If approved by the Engineer, an alternate indicator may be used for admixtures dosed at rates of 25 oz/cwt (1630 mL/100 kg) or greater, such as accelerating admixtures, corrosion inhibitors, and viscosity modifying admixtures."

Revise the first two sections of Check Sheet #11 of the Supplemental Specifications and Recurring Special Provisions to read:

"Description. This work shall consist of filling voids beneath rigid and composite pavements with cement grout.

Materials. Materials shall be according to the following Articles of Division 1000 - Materials of the Standard Specifications:

Item	Article/Section
(a) Cement	1001
(b) Water	1002
(c) Fly Ash	1010
(d) Ground Granulated Blast Furnace (GGBF) Slag.....	1010
(e) Admixtures	1021
(f) Packaged Rapid Hardening Mortar or Concrete	1018"

Revise the third paragraph of Materials Note 2 of Check Sheet #28 of the Supplemental Specifications and Recurring Special Provisions to read:

"The Department will maintain a qualified product list of synthetic fibers, which will include the minimum required dosage rate. For the minimum required fiber dosage rate based on the Illinois Modified ASTM C 1609 test, a report prepared by an independent laboratory accredited by AASHTO re:source for Portland Cement Concrete shall be provided. The report shall show results of tests conducted no more than five years prior to the time of submittal."

COMPENSABLE DELAY COSTS (BDE)

Effective: June 2, 2017

Revised: April 1, 2019

Revise Article 107.40(b) of the Standard Specifications to read:

“(b) Compensation. Compensation will not be allowed for delays, inconveniences, or damages sustained by the Contractor from conflicts with facilities not meeting the above definition; or if a conflict with a utility in an unanticipated location does not cause a shutdown of the work or a documentable reduction in the rate of progress exceeding the limits set herein. The provisions of Article 104.03 notwithstanding, compensation for delays caused by a utility in an unanticipated location will be paid according to the provisions of this Article governing minor and major delays or reduced rate of production which are defined as follows.

- (1) Minor Delay. A minor delay occurs when the work in conflict with the utility in an unanticipated location is completely stopped for more than two hours, but not to exceed two weeks.
- (2) Major Delay. A major delay occurs when the work in conflict with the utility in an unanticipated location is completely stopped for more than two weeks.
- (3) Reduced Rate of Production Delay. A reduced rate of production delay occurs when the rate of production on the work in conflict with the utility in an unanticipated location decreases by more than 25 percent and lasts longer than seven calendar days.”

Revise Article 107.40(c) of the Standard Specifications to read:

“(c) Payment. Payment for Minor, Major, and Reduced Rate of Production Delays will be made as follows.

- (1) Minor Delay. Labor idled which cannot be used on other work will be paid for according to Article 109.04(b)(1) and (2) for the time between start of the delay and the minimum remaining hours in the work shift required by the prevailing practice in the area.

Equipment idled which cannot be used on other work, and which is authorized to standby on the project site by the Engineer, will be paid for according to Article 109.04(b)(4).

- (2) Major Delay. Labor will be the same as for a minor delay.

Equipment will be the same as for a minor delay, except Contractor-owned equipment will be limited to two weeks plus the cost of move-out to either the Contractor's yard or another job and the cost to re-mobilize, whichever is less. Rental equipment may be paid for longer than two weeks provided the Contractor presents adequate support to the Department (including lease agreement) to show retaining equipment on the job is the most economical course to follow and in the public interest.

- (3) Reduced Rate of Production Delay. The Contractor will be compensated for the reduced productivity for labor and equipment time in excess of the 25 percent threshold for that portion of the delay in excess of seven calendar days. Determination of compensation will be in accordance with Article 104.02, except labor and material additives will not be permitted.

Payment for escalated material costs, escalated labor costs, extended project overhead, and extended traffic control will be determined according to Article 109.13.”

Revise Article 108.04(b) of the Standard Specifications to read:

“(b) No working day will be charged under the following conditions.

- (1) When adverse weather prevents work on the controlling item.
- (2) When job conditions due to recent weather prevent work on the controlling item.
- (3) When conduct or lack of conduct by the Department or its consultants, representatives, officers, agents, or employees; delay by the Department in making the site available; or delay in furnishing any items required to be furnished to the Contractor by the Department prevents work on the controlling item.
- (4) When delays caused by utility or railroad adjustments prevent work on the controlling item.
- (5) When strikes, lock-outs, extraordinary delays in transportation, or inability to procure critical materials prevent work on the controlling item, as long as these delays are not due to any fault of the Contractor.
- (6) When any condition over which the Contractor has no control prevents work on the controlling item.”

Revise Article 109.09(f) of the Standard Specifications to read:

- “(f) Basis of Payment. After resolution of a claim in favor of the Contractor, any adjustment in time required for the work will be made according to Section 108. Any adjustment in the costs to be paid will be made for direct labor, direct materials, direct equipment, direct jobsite overhead, direct offsite overhead, and other direct costs allowed by the resolution. Adjustments in costs will not be made for interest charges, loss of anticipated profit, undocumented loss of efficiency, home office overhead and unabsorbed overhead other than as allowed by Article 109.13, lost opportunity, preparation of claim expenses and other consequential indirect costs regardless of method of calculation.

The above Basis of Payment is an essential element of the contract and the claim cost recovery of the Contractor shall be so limited.”

Add the following to Section 109 of the Standard Specifications.

“109.13 Payment for Contract Delay. Compensation for escalated material costs, escalated labor costs, extended project overhead, and extended traffic control will be allowed when such costs result from a delay meeting the criteria in the following table.

VARIOUS ROUTES
SECTION DIST 8 PS 2025-1
MADISON, ST. CLAIR, AND MARION COUNTIES
CONTRACT NO. 76U37

Contract Type	Cause of Delay	Length of Delay
Working Days	Article 108.04(b)(3) or Article 108.04(b)(4)	No working days have been charged for two consecutive weeks.
Completion Date	Article 108.08(b)(1) or Article 108.08(b)(7)	The Contractor has been granted a minimum two week extension of contract time, according to Article 108.08.

Payment for each of the various costs will be according to the following.

- (a) Escalated Material and/or Labor Costs. When the delay causes work, which would have otherwise been completed, to be done after material and/or labor costs have increased, such increases will be paid. Payment for escalated material costs will be limited to the increased costs substantiated by documentation furnished by the Contractor. Payment for escalated labor costs will be limited to those items in Article 109.04(b)(1) and (2), except the 35 percent and 10 percent additives will not be permitted.
- (b) Extended Project Overhead. For the duration of the delay, payment for extended project overhead will be paid as follows.
- (1) Direct Jobsite and Offsite Overhead. Payment for documented direct jobsite overhead and documented direct offsite overhead, including onsite supervisory and administrative personnel, will be allowed according to the following table.

Original Contract Amount	Supervisory and Administrative Personnel
Up to \$5,000,000	One Project Superintendent
Over \$ 5,000,000 - up to \$25,000,000	One Project Manager, One Project Superintendent or Engineer, and One Clerk
Over \$25,000,000 - up to \$50,000,000	One Project Manager, One Project Superintendent, One Engineer, and One Clerk
Over \$50,000,000	One Project Manager, Two Project Superintendents, One Engineer, and One Clerk

- (2) Home Office and Unabsorbed Overhead. Payment for home office and unabsorbed overhead will be calculated as 8 percent of the total delay cost.
- (c) Extended Traffic Control. Traffic control required for an extended period of time due to the delay will be paid for according to Article 109.04.

When an extended traffic control adjustment is paid under this provision, an adjusted unit price as provided for in Article 701.20(a) for increase or decrease in the value of work by more than ten percent will not be paid.

Upon payment for a contract delay under this provision, the Contractor shall assign subrogation rights to the Department for the Department's efforts of recovery from any other party for monies paid by the Department as a result of any claim under this provision. The Contractor shall fully cooperate with the Department in its efforts to recover from another party any money paid to the Contractor for delay damages under this provision."

CONSTRUCTION AIR QUALITY – DIESEL RETROFIT (BDE)

Effective: June 1, 2010

Revised: January 1, 2025

The reduction of emissions of particulate matter (PM) for off-road equipment shall be accomplished by installing retrofit emission control devices. The term "equipment" refers to diesel fuel powered devices rated at 50 hp and above, to be used on the jobsite in excess of seven calendar days over the course of the construction period on the jobsite (including rental equipment).

Contractor and subcontractor diesel powered off-road equipment assigned to the contract shall be retrofitted according to the table below.

Horsepower Range	Model Year and Older
50-99	2003
100-299	2002
300-599	2000
600-749	2001
750 and up	2005

The retrofit emission control devices shall achieve a minimum PM emission reduction of 50 percent and shall be:

- a) Included on the U.S. Environmental Protection Agency (USEPA) *Verified Retrofit Technology List* (<https://www.epa.gov/verified-diesel-tech/verified-technologies-list-clean-diesel>), or verified by the California Air Resources Board (CARB) (<http://www.arb.ca.gov/diesel/verdev/vt/cvt.htm>); or
- b) Retrofitted with a non-verified diesel retrofit emission control device if verified retrofit emission control devices are not available for equipment proposed to be used on the project, and if the Contractor has obtained a performance certification from the retrofit device manufacturer that the emission control device provides a minimum PM emission reduction of 50 percent.

Note: Large cranes (Crawler mounted cranes) which are responsible for critical lift operations are exempt from installing retrofit emission control devices if such devices adversely affect equipment operation.

Diesel powered off-road equipment with engine ratings of 50 hp and above, which are unable to be retrofitted with verified emission control devices or if performance certifications are not available which will achieve a minimum 50 percent PM reduction, may be granted a waiver by the Department if documentation is provided showing good faith efforts were made by the Contractor to retrofit the equipment.

Construction shall not proceed until the Contractor submits a certified list of the diesel powered off-road equipment that will be used, and as necessary, retrofitted with emission control devices. The list(s) shall include (1) the equipment number, type, make, Contractor/rental company name; and (2) the emission control devices make, model, USEPA or CARB verification number, or performance certification from the retrofit device manufacturer. Equipment reported as fitted with emissions control devices shall be made available to the Engineer for visual inspection of the device installation, prior to being used on the jobsite.

The Contractor shall submit an updated list of retrofitted off-road construction equipment as retrofitted equipment changes or comes on to the jobsite. The addition or deletion of any diesel powered equipment shall be included on the updated list.

If any diesel powered off-road equipment is found to be in non-compliance with any portion of this special provision, the Engineer will issue the Contractor a diesel retrofit deficiency deduction.

Any costs associated with retrofitting any diesel powered off-road equipment with emission control devices shall be considered as included in the contract unit prices bid for the various items of work involved and no additional compensation will be allowed. The Contractor's compliance with this notice and any associated regulations shall not be grounds for a claim.

Diesel Retrofit Deficiency Deduction

When the Engineer determines that a diesel retrofit deficiency exists, a daily monetary deduction will be imposed for each calendar day or fraction thereof the deficiency continues to exist. The calendar day(s) will begin when the time period for correction is exceeded and end with the Engineer's written acceptance of the correction. The daily monetary deduction will be \$1,000.00 for each deficiency identified.

The deficiency will be based on lack of diesel retrofit emissions control.

If a Contractor accumulates three diesel retrofit deficiency deductions for the same piece of equipment in a contract period, the Contractor will be shutdown until the deficiency is corrected. Such a shutdown will not be grounds for any extension of the contract time, waiver of penalties, or be grounds for any claim.

DISADVANTAGED BUSINESS ENTERPRISE PARTICIPATION (DBE)

Effective: September 1, 2000

Revised: January 2, 2025

1. OVERVIEW AND GENERAL OBLIGATION. The Department of Transportation, as a recipient of federal financial assistance, is required to take all necessary and reasonable steps to ensure nondiscrimination in the award and administration of contracts. Consequently, the federal regulatory provisions of 49 CFR Part 26 apply to this contract concerning the utilization of disadvantaged business enterprises. For the purposes of this Special Provision, a disadvantaged business enterprise (DBE) means a business certified in accordance with the requirements of 49 CFR Part 26 and listed in the Illinois Unified Certification Program (IL UCP) DBE Directory. Award of the contract is conditioned on meeting the requirements of 49 CFR Part 26, and failure by the Contractor to carry out the requirements of Part 26 is a material breach of the contract and may result in the termination of the contract or such other remedies as the Department deems appropriate.
2. CONTRACTOR ASSURANCE. All assurances set forth in FHWA 1273 are hereby incorporated by reference and will be physically attached to the final contract and all subcontracts.
3. CONTRACT GOAL TO BE ACHIEVED BY THE CONTRACTOR. The Department has determined the work of this contract has subcontracting opportunities that may be suitable for performance by DBE companies and that, in the absence of unlawful discrimination and in an arena of fair and open competition, DBE companies can be expected to perform **0.00 %** of the work. This percentage is set as the DBE participation goal for this contract. Consequently, in addition to the other award criteria established for this contract, the Department will only award this contract to a bidder who makes a good faith effort to meet this goal of DBE participation in the performance of the work in accordance with the requirements of 49 CFR 26.53 and SBE Memorandum No. 24-02.
4. IDENTIFICATION OF CERTIFIED DBE. Information about certified DBE Contractors can be found in the Illinois UCP Directory. Bidders can obtain additional information and assistance with identifying DBE-certified companies at the Department's website or by contacting the Department's Bureau of Small Business Enterprises at (217) 785-4611.
5. BIDDING PROCEDURES. Compliance with this Special Provision and SBE Policy Memorandum 24-02 is a material bidding requirement. The following shall be included with the bid.
 - (a) DBE Utilization Plan (form SBE 2026) documenting enough DBE participation has been obtained to meet the goal, or a good faith effort has been made to meet the goal even though the efforts did not succeed in obtaining enough DBE participation to meet the goal.
 - (b) Applicable DBE Participation Statement (form SBE 2023, 2024, and/or 2025) for each DBE firm the bidder has committed to perform the work to achieve the contract goal.

The required forms and documentation shall be submitted as a single .pdf file using the "Integrated Contractor Exchange (iCX)" application within the Department's "EBids System".

The Department will not accept a bid if it does not meet the bidding procedures set forth herein and the bid will be declared non-responsive. A bidder declared non-responsive for failure to meet the bidding procedures will not give rise to an administrative reconsideration. In the event the bid is declared non-responsive, the Department may elect to cause the forfeiture of the penal sum of the bidder's proposal guaranty and may deny authorization to bid the project if re-advertised for bids.

6. UTILIZATION PLAN EVALUATION. The contract will not be awarded until the Utilization Plan is approved. All information submitted by the bidder must be complete, accurate, and adequately document the bidder has committed to DBE participation sufficient to meet the goal, or that the bidder has made good faith efforts to do so, in the event the bidder cannot meet the goal, in order for the Department to commit to the performance of the contract by the bidder.

The Utilization Plan will be approved by the Department if the Utilization Plan documents sufficient commercially useful DBE work to meet the contract goal or the Department determines, based upon the documentation submitted, that the bidder has made a good faith effort to meet the contract goal pursuant to 49 CFR Part 26, Appendix A and the requirements of SBE 2026.

If the Department determines that a good faith effort has not been made, the Department will notify the responsible company official designated in the Utilization Plan of that determination in accordance with SBE Policy Memorandum 24-02.

7. CALCULATING DBE PARTICIPATION. The Utilization Plan values represent work the bidder commits to have performed by the specified DBEs and paid for upon satisfactory completion. The Department is only able to count toward the achievement of the overall goal and the contract goal the value of payments made for the work actually performed by DBE firms. In addition, a DBE must perform a commercially useful function on the contract to be counted. A commercially useful function is generally performed when the DBE is responsible for the work and is carrying out its responsibilities by actually performing, managing, and supervising the work involved. The Department and Contractor are governed by the provisions of 49 CFR Part 26.55(c) on questions of commercially useful functions as it affects the work. Specific guidelines for counting goal credit are provided in 49 CFR Part 26.55. In evaluating Utilization Plans for award the Department will count goal credit as set forth in Part 26 and in accordance with SBE Policy Memorandum 24-02.
8. CONTRACT COMPLIANCE. The Contractor must utilize the specific DBEs listed to perform the work and supply the materials for which each DBE is listed in the Contractor's approved Utilization Plan, unless the Contractor obtains the Department's written consent to terminate the DBE or any portion of its work. The DBE Utilization Plan approved by SBE is a condition-of-award, and any deviation to that Utilization Plan, the work set forth therein to be performed by DBE firms, or the DBE firms specified to perform that work, must be approved, in writing, by the Department in accordance with federal regulatory requirements. Deviation from the DBE Utilization Plan condition-of-award without such written approval is a violation of the contract and may result in termination of the contract or such other remedy the Department deems appropriate. The following administrative procedures and remedies govern the compliance by the Contractor with the contractual obligations established by the Utilization Plan.

- (a) NOTICE OF DBE PERFORMANCE. The Contractor shall provide the Engineer with at least three days advance notice of when all DBE firms are expected to perform the work committed under the Contractor's Utilization Plan.
- (b) SUBCONTRACT. If awarded the contract, the Contractor is required to enter into written subcontracts with all DBE firms indicated in the approved Utilization Plan and must provide copies of fully executed DBE subcontracts to the Department upon request. Subcontractors shall ensure that all lower tier subcontracts or agreements with DBEs to supply labor or materials be performed in accordance with this Special Provision.
- (c) PAYMENT TO DBE FIRMS. The Department is prohibited by federal regulations from crediting the participation of a DBE included in the Utilization Plan toward either the contract goal or the Department's overall goal until the amount to be applied toward the goal has been paid to the DBE. The Contractor shall document and report all payments for work performed by DBE certified firms in accordance with Article 109.11 of the Standard Specifications. All records of payment for work performed by DBE certified firms shall be made available to the Department upon request.
- (d) FINAL PAYMENT. After the performance of the final item of work or trucking, or delivery of material by a DBE and final payment to the DBE by the Contractor, but not later than 30 calendar days after payment has been made by the Department to the Contractor for such work or material, the Contractor shall submit a DBE Payment Agreement (form SBE 2115) to the Engineer. If the Contractor does not have the full amount of work indicated in the Utilization Plan performed by the DBE companies indicated in the Utilization Plan and after good faith efforts are reviewed, the Department may deduct from contract payments to the Contractor the amount of the goal not achieved as liquidated and ascertained damages.
- (g) ENFORCEMENT. The Department reserves the right to withhold payment to the Contractor to enforce the provisions of this Special Provision. Final payment shall not be made on the contract until such time as the Contractor submits sufficient documentation demonstrating achievement of the goal in accordance with this Special Provision or after liquidated damages have been determined and collected.

REMOVAL AND DISPOSAL OF REGULATED SUBSTANCES (BDE)

Effective: January 1, 2024

Revised: April 1, 2024

Revise the first paragraph of Article 669.04 of the Standard Specifications to read:

“669.04 Regulated Substances Monitoring. Regulated substances monitoring includes environmental observation and field screening during regulated substances management activities. The excavated soil and groundwater within the work areas shall be managed as either uncontaminated soil, hazardous waste, special waste, or non-special waste.

As part of the regulated substances monitoring, the monitoring personnel shall perform and document the applicable duties listed on form BDE 2732 “Regulated Substances Monitoring Daily Record (RSMDR)”.

Revise the first two sentences of the nineteenth paragraph of Article 669.05 of the Standard Specifications to read:

“The Contractor shall coordinate waste disposal approvals with the disposal facility and provide the specific analytical testing requirements of that facility. The Contractor shall make all arrangements for collection, transportation, and analysis of landfill acceptance testing.”

Revise the last paragraph of Article 669.05 of the Standard Specifications to read:

“The Contractor shall select a permitted landfill facility or CCDD/USFO facility meeting the requirements of 35 Ill. Admin. Code Parts 810-814 or Part 1100, respectively. The Department will review and approve or reject the facility proposed by the Contractor based upon information provided in BDE 2730. The Contractor shall verify whether the selected facility is compliant with those applicable standards as mandated by their permit and whether the facility is presently, has previously been, or has never been, on the United States Environmental Protection Agency (U.S. EPA) National Priorities List or the Resource Conservation and Recovery Act (RCRA) List of Violating Facilities. The use of a Contractor selected facility shall in no manner delay the construction schedule or alter the Contractor's responsibilities as set forth.”

Revise the first paragraph of Article 669.07 of the Standard Specifications to read:

“669.07 Temporary Staging. Soil classified according to Articles 669.05(a)(2), (b)(1), or (c) may be temporarily staged at the Contractor's option. All other soil classified according to Articles 669.05(a)(1), (a)(3), (a)(4), (a)(5), (a)(6), or (b)(2) shall be managed and disposed of without temporary staging to the greatest extent practicable. If circumstances beyond the Contractor's control require temporary staging of these latter materials, the Contractor shall request approval from the Engineer in writing.

Topsoil for re-use as final cover which has been field screened and found not to exhibit PID readings over daily background readings as documented on the BDE 2732, visual staining or odors, and is classified according to Articles 669.05(a)(2), (a)(3), (a)(4), (b)(1), or (c) may be temporarily staged at the Contractor's option.”

Add the following paragraph after the sixth paragraph of Article 669.11 of the Standard Specifications.

“The sampling and testing of effluent water derived from dewatering discharges for priority pollutants volatile organic compounds (VOCs), priority pollutants semi-volatile organic compounds (SVOCs), or priority pollutants metals, will be paid for at the contract unit price per each for VOCS GROUNDWATER ANALYSIS using EPA Method 8260B, SVOCs GROUNDWATER ANALYSIS using EPA Method 8270C, or RCRA METALS GROUNDWATER ANALYSIS using EPA Methods 6010B and 7471A. This price shall include transporting the sample from the job site to the laboratory.”

Revise the first sentence of the eight paragraph of Article 669.11 of the Standard Specifications to read:

“Payment for temporary staging of soil classified according to Articles 669.05(a)(1), (a)(3), (a)(4), (a)(5), (a)(6), or (b)(2) to be managed and disposed of, if required and approved by the Engineer, will be paid according to Article 109.04.”

SUBCONTRACTOR AND DBE PAYMENT REPORTING (BDE)

Effective: April 2, 2018

Add the following to Section 109 of the Standard Specifications.

“109.14 Subcontractor and Disadvantaged Business Enterprise Payment Reporting.
The Contractor shall report all payments made to the following parties:

- (a) first tier subcontractors;
- (b) lower tier subcontractors affecting disadvantaged business enterprise (DBE) goal credit;
- (c) material suppliers or trucking firms that are part of the Contractor’s submitted DBE utilization plan.

The report shall be made through the Department’s on-line subcontractor payment reporting system within 21 days of making the payment.”

SUBCONTRACTOR MOBILIZATION PAYMENTS (BDE)

Effective: November 2, 2017

Revised: April 1, 2019

Replace the second paragraph of Article 109.12 of the Standard Specifications with the following:

“This mobilization payment shall be made at least seven days prior to the subcontractor starting work. The amount paid shall be at the following percentage of the amount of the subcontract reported on form BC 260A submitted for the approval of the subcontractor’s work.

Value of Subcontract Reported on Form BC 260A	Mobilization Percentage
Less than \$10,000	25%
\$10,000 to less than \$20,000	20%
\$20,000 to less than \$40,000	18%
\$40,000 to less than \$60,000	16%
\$60,000 to less than \$80,000	14%
\$80,000 to less than \$100,000	12%
\$100,000 to less than \$250,000	10%
\$250,000 to less than \$500,000	9%
\$500,000 to \$750,000	8%
Over \$750,000	7%”

SUBMISSION OF BIDDERS LIST INFORMATION (BDE)

Effective: January 2, 2025

Revised: March 2, 2025

In accordance with 49 CFR 26.11(c) all DBE and non-DBEs who bid as prime contractors and subcontractors shall provide bidders list information, including all DBE and non-DBE firms from whom the bidder has received a quote or bid to work as a subcontractor, whether or not the bidder has relied upon that bid in placing its bid as the prime contractor.

The bidders list information shall be submitted with the bid using the link provided within the "Integrated Contractor Exchange (iCX)" application of the Department's "EBids System".

SUBMISSION OF PAYROLL RECORDS (BDE)

Effective: April 1, 2021

Revised: November 2, 2023

FEDERAL AID CONTRACTS. Revise the following section of Check Sheet #1 of the Recurring Special Provisions to read:

"STATEMENTS AND PAYROLLS

The payroll records shall include the worker's name, social security number, last known address, telephone number, email address, classification(s) of work actually performed, hourly rates of wages paid (including rates of contributions or costs anticipated for bona fide fringe benefits or cash equivalents thereof), daily and weekly number of hours actually worked in total, deductions made, and actual wages paid.

The Contractor and each subcontractor shall submit certified payroll records to the Department each week from the start to the completion of their respective work, except that full social security numbers, last known addresses, telephone numbers, and email addresses shall not be included on weekly submittals. Instead, the payrolls need only include an identification number for each employee (e.g., the last four digits of the employee's social security number). The submittals shall be made using LCPTracker Pro software. The software is web-based and can be accessed at <https://lcptracker.com/>. When there has been no activity during a work week, a payroll record shall still be submitted with the appropriate option ("No Work", "Suspended", or "Complete") selected."

STATE CONTRACTS. Revise Item 3 of Section IV of Check Sheet #5 of the Recurring Special Provisions to read:

- "3. Submission of Payroll Records. The Contractor and each subcontractor shall, no later than the 15th day of each calendar month, file a certified payroll for the immediately preceding month to the Illinois Department of Labor (IDOL) through the Illinois Prevailing Wage Portal in compliance with the State Prevailing Wage Act (820 ILCS 130). The portal can be found on the IDOL website at <https://www2.illinois.gov/idol/Laws-Rules/CONMED/Pages/Prevailing-Wage-Portal.aspx>. Payrolls shall be submitted in the format prescribed by the IDOL.

In addition to filing certified payroll(s) with the IDOL, the Contractor and each subcontractor shall certify and submit payroll records to the Department each week from the start to the completion of their respective work, except that full social security numbers shall not be included on weekly submittals. Instead, the payrolls shall include an identification number for each employee (e.g., the last four digits of the employee's social security number). In addition, starting and ending times of work each day may be omitted from the payroll records submitted. The submittals shall be made using LCPtracker Pro software. The software is web-based and can be accessed at <https://lcptracker.com/>. When there has been no activity during a work week, a payroll record shall still be submitted with the appropriate option ("No Work", "Suspended", or "Complete") selected."

SURVEYING SERVICES (BDE)

Effective: April 1, 2025

Delete the fourth paragraph of Article 667.04 of the Standard Specifications.

Delete Section 668 of the Standard Specifications.

WEEKLY DBE TRUCKING REPORTS (BDE)

Effective: June 2, 2012

Revised: January 2, 2025

The following applies to all Disadvantaged Business Enterprise (DBE) trucks on the project, whether they are utilized for DBE goal credit or not.

The Contractor shall notify the Engineer at least three days prior to DBE trucking activity.

The Contractor shall submit a weekly report of DBE trucks hired by the Contractor or subcontractors (i.e. not owned by the Contractor or subcontractors) to the Engineer on Department form "SBE 723" within ten business days following the reporting period. The reporting period shall be Sunday through Saturday for each week reportable trucking activities occur.

Any costs associated with providing weekly DBE trucking reports shall be considered as included in the contract unit prices bid for the various items of work involved and no additional compensation will be allowed.

WORK ZONE TRAFFIC CONTROL DEVICES (BDE)

Effective: March 2, 2020

Revised: January 1, 2025

Add the following to Article 701.03 of the Standard Specifications:

“(q) Temporary Sign Supports 1106.02”

Revise the third paragraph of Article 701.14 of the Standard Specifications to read:

“For temporary sign supports, the Contractor shall provide a FHWA eligibility letter for each device used on the contract. The letter shall provide information for the set-up and use of the device as well as a detailed drawing of the device. The signs shall be supported within 20 degrees of vertical. Weights used to stabilize signs shall be attached to the sign support per the manufacturer’s specifications.”

Revise the first paragraph of Article 701.15 of the Standard Specifications to read:

“ **701.15 Traffic Control Devices.** For devices that must meet crashworthiness standards, the Contractor shall provide a manufacturer’s self-certification or a FHWA eligibility letter for each Category 1 device and a FHWA eligibility letter for each Category 2 and Category 3 device used on the contract. The self-certification or letter shall provide information for the set-up and use of the device as well as a detailed drawing of the device.”

Revise the first six paragraphs of Article 1106.02 of the Standard Specifications to read:

“ **1106.02 Devices.** Work zone traffic control devices and combinations of devices shall meet crashworthiness standards for their respective categories. The categories are as follows.

Category 1 includes small, lightweight, channelizing and delineating devices that have been in common use for many years and are known to be crashworthy by crash testing of similar devices or years of demonstrable safe performance. These include cones, tubular markers, plastic drums, and delineators, with no attachments (e.g. lights). Category 1 devices shall be MASH compliant.

Category 2 includes devices that are not expected to produce significant vehicular velocity change but may otherwise be hazardous. These include vertical panels with lights, barricades, temporary sign supports, and Category 1 devices with attachments (e.g. drums with lights). Category 2 devices shall be MASH compliant.

Category 3 includes devices that are expected to cause significant velocity changes or other potentially harmful reactions to impacting vehicles. These include crash cushions (impact attenuators), truck mounted attenuators, and other devices not meeting the definitions of Category 1 or 2. Category 3 devices manufactured after December 31, 2019 shall be MASH compliant. Category 3 devices manufactured on or before December 31, 2019, and compliant with NCHRP 350, may be used on contracts let before December 31, 2029. Category 3 devices shall be crash tested for Test Level 3 or the test level specified.

Category 4 includes portable or trailer-mounted devices such as sign supports, speed feedback displays, arrow boards, changeable message signs, temporary traffic signals, and area lighting supports. It is preferable for Category 4 devices manufactured after December 31, 2019 to be MASH-16 compliant; however, there are currently no crash tested devices in this category, so it remains exempt from the NCHRP 350 or MASH compliance requirement.

For each type of device, when no more than one MASH compliant is available, an NCHRP 350 compliant device may be used, even if manufactured after December 31, 2019.”

Revise Articles 1106.02(g), 1106.02(k), and 1106.02(l) to read:

“(g) Truck Mounted/Trailer Mounted Attenuators. The attenuator shall be approved for use at Test Level 3. Test Level 2 may be used for normal posted speeds less than or equal to 45 mph.

(k) Temporary Water Filled Barrier. The water filled barrier shall be a lightweight plastic shell designed to accept water ballast and be on the Department’s qualified product list.

Shop drawings shall be furnished by the manufacturer and shall indicate the deflection of the barrier as determined by acceptance testing; the configuration of the barrier in that test; and the vehicle weight, velocity, and angle of impact of the deflection test. The Engineer shall be provided one copy of the shop drawings.

(l) Movable Traffic Barrier. The movable traffic barrier shall be on the Department’s qualified product list.

Shop drawings shall be furnished by the manufacturer and shall indicate the deflection of the barrier as determined by acceptance testing; the configuration of the barrier in that test; and the vehicle weight, velocity, and angle of impact of the deflection test. The Engineer shall be provided one copy of the shop drawings. The barrier shall be capable of being moved on and off the roadway on a daily basis.”

WORKING DAYS (BDE)

Effective: January 1, 2002

The Contractor shall complete the work within **205** working days.

REVISIONS TO THE ILLINOIS PREVAILING WAGE RATES

The Prevailing rates of wages are included in the Contract proposals which are subject to Check Sheet #5 of the Supplemental Specifications and Recurring Special Provisions. The rates have been ascertained and certified by the Illinois Department of Labor for the locality in which the work is to be performed and for each craft or type of work or mechanic needed to execute the work of the Contract. As required by Prevailing Wage Act (820 ILCS 130/0.01, et seq.) and Check Sheet #5 of the Contract, not less than the rates of wages ascertained by the Illinois Department of Labor and as revised during the performance of a Contract shall be paid to all laborers, workers and mechanics performing work under the Contract. Post the scale of wages in a prominent and easily accessible place at the site of work.

If the Illinois Department of Labor revises the prevailing rates of wages to be paid as listed in the specification of rates, the contractor shall post the revised rates of wages and shall pay not less than the revised rates of wages. Current wage rate information shall be obtained by visiting the Illinois Department of Labor web site at <http://www.state.il.us/agency/idol/> or by calling 312-793-2814. It is the responsibility of the contractor to review the rates applicable to the work of the contract at regular intervals in order to insure the timely payment of current rates. Provision of this information to the contractor by means of the Illinois Department of Labor web site satisfies the notification of revisions by the Department to the contractor pursuant to the Act, and the contractor agrees that no additional notice is required. The contractor shall notify each of its subcontractors of the revised rates of wages.