City of Thornton
WBWTP PAC Facility Improvements
Technical Specifications

Issued for Bid

October 2026

City of Thornton Project No. 24-149

Burns & McDonnell Project No. 177918

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CLIENT NAME	City of Thornton
PROJECT NAME	WBWTP PAC Facility Improvements
CLIENT CIP NO.	24-149
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SPECIFICATION INDEX

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CERTIFICATION(S)

END OF SECTION 00 01 07

DIVISION 01 – GENERAL REQUIREMENTS

SECTION 01 11 00 – SUMMARY OF WORK

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section summarizes the Work covered in detail in the complete Contract Documents.
   1. Owner: City of Thornton is contracting for the Work described in the Contract Documents.
      a. Contract Identification: City of Thornton – Wes Brown Water Treatment Plant PAC Improvements Project. Project No. 24-147.149
      b. Work Site Location:
         Wes Brown Water Treatment Plant (WBWTP)
         3651 E 86th Ave
         Thornton, Colorado 80229

B. Engineer: The Plans and Specifications were prepared by Burns & McDonnell Engineering Company, Inc. 9191 Jamaica Way Englewood, CO 80112.

1.02 PROJECT DESCRIPTION:

A. Description of Project: The City of Thornton is installing a bulk chemical silo and screw conveyor feed system for additional onsite storage of powdered activated carbon (PAC). A foundation pad suitable for two (2) storage silos will be constructed, with the second silo being planned for future installation. The silo and feed will be compatible with the existing PAC Pretreatment Facility. The City of Thornton is also adding a TSS meter and free chlorine probe at the sludge lagoon overflow structure prior to discharge to the Gravel Lakes system.

B. All work, whether indicated specifically or not, shall be for a fully functional and complete system.

1.03 WORK BY OTHERS:

A. Work Under Other Contracts: None
B. Work by Owner: None
C. Other Activities: None

1.04 CONTRACTOR USE OF PREMISES:

A. Limited Use:
   1. Limit use of the premises for storage and execution of the Work to allow for Owner occupancy.
   2. Coordinate with Owner to avoid interference of operations.
   3. Conduct operations so as to ensure the least inconvenience to Owner.

B. Contractor shall conform to partial use and right of occupancy requirements outlined in the GENERAL CONDITIONS.

1.05 OWNER'S USE OF PREMISES:

A. Full Owner Occupancy: The Owner will occupy the Site during the entire construction period. Cooperate with the Owner during construction operations to minimize conflicts and facilitate Owner usage. Perform the Work so as not to interfere with the Owner's operations.

1.06 WORK AREA RESTRICTIONS:

A. Work hours are 6:30 AM to 5:00 PM, Monday through Friday.

B. After hour and weekend work shall be coordinated with the Owner, the Engineer, and Contractor will be subject to reimbursement to the Owner for observation time associated with such after-hour work and weekend work. All after-hour or weekend work must first be requested and approved by the Owner.

C. No work shall take place on the following holidays observed by Owner:
   1. New Year's Day
   2. Martin Luther King Jr. Day
   3. President's Day
   4. Memorial Day
   5. Juneteenth
   6. Independence Day
   7. Labor Day
   8. Veterans Day
   9. Thanksgiving Day
   10. Day after Thanksgiving
   11. Christmas Eve Day
   12. Christmas Day

1.07 SITE ACCESS:

A. Access to the Project site shall be through City of Thornton-owned roads at WBWTP.
   1. Contractors bid shall include necessary costs to restore the site access to existing or better condition after construction. This shall include all work, labor, and equipment necessary to protect, restore, rehabilitate, or replace any damaged landscaping or hardscaping. Contractor's bid shall also include all necessary costs to maintain the roadways during construction as needed, and upon request by the Owner.
   2. Contractor shall comply with road, traffic, travel control, and maintenance requirements outlined in GENERAL CONDITIONS.

1.08 WORK SEQUENCE:

A. General: Construction sequence shall be determined by Contractor subject to Owner's need for continuous operation of existing facilities.

B. Continuous Service of Existing Facilities: Exercise caution and schedule operations to ensure that functionality of present facilities will not be disrupted. Shutdown of Owner's operating facilities to perform the Work shall be held to a minimum length of time and shall be coordinated with Owner who shall have control over the timing and schedules of such shutdowns.

1.09 MEASUREMENT AND PAYMENT:

A. Lump Sum Contracts: All Work indicated and specified in the Contract Documents shall be included in the Lump Sum Contract Price.

1.10 NOISE AND VIBRATIONS

A. Construction will take place near a residential area. The Contractor shall comply with noise and vibration requirements as described in the City of Thornton Municipal Code, Chapter 38 Section 38-441.

B. All equipment alarms shall not exceed 55 decibels (dBA), the Contractor is required to modify equipment at no additional cost to the Owner to meet listed noise and vibration requirements specified.

C. Provide white noise backup alarm on construction equipment.

1.11 LIST OF DRAWINGS (AND SCHEDULES):

A. Contract Drawings:

1. Each sheet of the Contract Drawings bears the following general title: CITY OF THORNTON – WBWTP PAC FACILITY IMPROVEMENTS

PART 2 - PRODUCTS - NOT APPLICABLE.

PART 3 - EXECUTION - NOT APPLICABLE.

END OF SECTION 01 11 00

SECTION 01 31 00 – PROJECT COORDINATION AND MEETINGS

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes administrative provisions for coordinating construction operations on Project including, but not limited to, the following:
   1. Coordination drawings.
   2. Project meetings.
   3. Requests for information (RFIs).

1.02 RELATED REQUIREMENTS:

A. For preparing and submitting Contractor's construction progress schedule: Section 01 32 00.
B. For Submittal Requirements: Section 01 33 00.
C. For coordinating closeout of the Contract: Section 01 78 00.

1.03 DEFINITIONS:

A. RFI: As defined in GENERAL CONDITIONS.

1.04 COORDINATION:

A. The Contractor shall coordinate operations in accordance with the GENERAL CONDITIONS and SPECIAL CONDITIONS and s further specified in this section. Contractor shall coordinate the completion of their activities with work performed by the Owner, any other Contractors, and other entities, to facilitate proper installation and construction. This includes all requirements specified in each Section of the contract.
   1. Schedule construction operations in sequence required to obtain the best results where installation of one part of the Work depends on installation of other components, before or after its own installation.
   2. Coordinate installation of different components with other contractors to allow optimum accessibility for required maintenance, service, and repair.
   3. Make adequate provisions to accommodate items scheduled for later installation.
   4. Where availability of space is limited, coordinate installation of different components to allow optimum performance and accessibility for required maintenance, service, and repair of all components, including mechanical and electrical.

B. Prepare memoranda for distribution to each party involved, outlining special procedures required for coordination. Include such items as required notices, reports, and list of attendees at meetings.
   1. Prepare similar memoranda for Owner and separate contractors if coordination of their Work is required.

C. Administrative Procedures: Coordinate scheduling and timing of required administrative procedures with other construction activities and activities of others to avoid conflicts and to ensure orderly progress of the Work. Such administrative activities include, but are not limited to, the following:
   1. Preparation of construction progress schedule.
   2. Preparation of the schedule of values.
   3. Installation and removal of temporary facilities and controls.
   4. Delivery and processing of Submittals.
   5. Progress meetings.
   6. Preinstallation conferences.
   7. Project closeout activities.
   8. Startup and adjustment of systems.

9. Project closeout activities.

1.05 SUBMITTALS:

A. Coordination Drawings: Prepare Coordination Drawings if limited space availability necessitates maximum utilization of space for efficient installation of different components or if coordination is required for installation of products and materials fabricated by separate entities.
   1. Content: Project-specific information, drawn accurately to scale. Do not base Coordination Drawings on reproductions of the Contract Documents or standard printed data. Include the following information, as applicable:
      a. Indicate functional and spatial relationships of components of architectural, structural, civil, mechanical, process, and electrical systems.
      b. Indicate required installation sequences.
      c. Indicate dimensions shown on the Contract Drawings and make specific note of dimensions that appear to be in conflict with submitted Equipment and minimum clearance requirements. Provide alternate sketches to Engineer for resolution of such conflicts. Minor dimension changes and difficult installations will not be considered changes to the Contract.
      d. Crane or other construction equipment placement and motion space required.
   2. Sheet Size: At least 8-1/2 by 11 inches but no larger than 30 by 40 inches.
   3. Number of Copies: Submit one electronic copy of each Submittal to Engineer. Engineer will return comments electronically.
   4. Refer to individual Sections for coordination drawing requirements for Work in those Sections.

1.06 PROJECT MEETINGS:

A. Preconstruction Conference:
   1. Engineer will conduct a meeting within 20 days after the Effective Date of the Agreement, to review items stated in the following agenda and to establish a working understanding between the parties as to their relationships during performance of the Work.
   2. Preconstruction conference shall be attended by:
      a. Representative(s) of Contractor including Contractor’s superintendent.
      b. Engineer.
      c. Representative(s) of Owner.
      d. At Owner's option, representatives of principal Subcontractors and Suppliers.
   3. Meeting Agenda:
      a. Construction schedules.
      b. Phasing.
      c. Critical Work sequencing and long-lead items.
      d. Designation of key personnel and their duties; lines of communication.
      e. Project coordination.
      f. Procedures and Processing of:
         (1) RFIs.
         (2) Field decisions.
         (3) Submittals.
         (4) Change Orders.
         (5) Applications for Payment.
      g. Procedures for testing.

h. Procedures for preparing and maintaining record documents.
i. Use of Premises:
(1) Office, work, storage, laydown, and parking areas.
(2) Owner's requirements.
(3) Work restrictions and hours.
j. Construction facilities, controls, and construction aids.
k. Temporary utilities.
l. Safety and first-aid.
m. Security.
n. Deliveries of Equipment and Materials.

4. Location of Meeting: Conference room in the WBWTP or via Microsoft Teams.
5. Reporting:
a. Within three working days after the meeting, Engineer will prepare and distribute minutes of the meeting to Owner and Contractor.
b. Contractor shall provide copies to Subcontractors and major Suppliers.

B. Construction Progress Meetings:
1. Construction progress meetings shall be conducted in accordance with the GENERAL CONDITIONS and SPECIAL CONDITIONS.
2. Location of Meetings: Conference room in the WBWTP or via Microsoft Teams.
3. Reporting:
a. Within three calendar days after each meeting, Contractor will prepare and distribute minutes of the meeting to Owner and Engineer.
b. Owner shall review minutes within seven calendar days of receipt for accuracy and completeness, and note modifications and/or corrections. Contractor shall incorporate modifications and/or corrections into the meeting minutes as deemed appropriate by Owner, and the revised meeting minutes will be re-distributed to all attendees by Contractor within 3 calendar days or prior to next meeting.
c. Contractor shall distribute copies to principal Subcontractors and Suppliers.

C. Preinstallation Conferences:
1. Contractor shall conduct a preinstallation conference at the Project Site before each construction activity that requires coordination with other construction and where required in Divisions 02 through 33.
2. Installer and representatives of manufacturers and fabricators, of products furnished by this Contract or by others, involved in or affected by the installation Work and its coordination or integration with other materials and installations, shall attend the meeting. Advise Engineer of scheduled meeting dates.
3. Review the progress of other construction activities and preparations for the particular activity under consideration at each preinstallation conference, including installation procedures and requirements for the following:
a. Contract Documents.
b. Options.
c. Related Change Orders.
d. Purchases.
e. Deliveries.
f. Shop Drawings, product data, and quality control Samples.
g. Review of mockups.
h. Possible conflicts.
i. Compatibility problems.
j. Time schedules.

k. Weather limitations.
l. Manufacturer's recommendations.
m. Warranty requirements.
n. Acceptability of substrates.
o. Temporary facilities and controls.
p. Space and access limitations.
q. Governing regulations.
r. Safety.
s. Inspecting and testing requirements.
t. Required performance results.
u. Recording requirements.
v. Protection of construction, personnel, and adjacent work.

4. Record significant discussions and agreements and disagreements of each conference. Distribute the minutes of the meeting within 3 working days after the meeting to everyone concerned, including Owner and Engineer.
5. Do not proceed with the installation if disagreements arise during the conference which cannot be successfully resolved at the time. Contractor shall take actions necessary to resolve impediments to performance of Work and reconvene the conference at the earliest feasible date.

D. Startup Coordination Meetings:
1. Contractor will conduct startup coordination meetings at the Site with prime contractors prior to starting up major equipment. Contractor, major Subcontractors, Engineer, and Owner shall attend and participate in the meetings.
2. Agenda:
a. Review of commissioning progress.
b. Safety, hazard, and risk consideration.
c. Startup observations and deviations from procedures.
d. Issues that may impede startup.
e. Construction interfaces affecting startup.
f. Delivery schedules.
g. Performance and acceptance testing.
h. Quality assurance and quality control issues.
i. Corrective and/or warranty issues.
j. Other items as appropriate.

1.07 REQUESTS FOR INFORMATION (RFI):

A. Procedure: Promptly on discovery of the need for interpretation of the Contract Documents, and if not possible to request interpretation at Project meeting, prepare and submit an RFI with the content specified.
1. RFIs shall originate with Contractor. RFIs submitted by entities other than Contractor will be returned with no response.
2. Coordinate and submit RFIs in a prompt manner to avoid delays in Contractor's Work or work of Subcontractors.

B. Content of the RFI: Include a detailed, legible description of item needing interpretation and the following:
1. Project name.
2. Date.
3. Name of Contractor.
4. Contract number and title.

5. Name of Engineer.
6. RFI number, numbered sequentially.
7. Specification Section number and title and related paragraphs, as appropriate.
8. Drawing number and detail references, as appropriate.
9. Field dimensions and conditions, as appropriate.
10. Contractor's suggested solution(s). If Contractor's solution(s) impact the Contract Times or the Contract Price, Contractor shall state impact in the RFI.
11. Contractor's signature.
12. Attachments: Include drawings, descriptions, measurements, photos, product data, Shop Drawings, and other information necessary to fully describe items needing interpretation.

C. Software-Generated RFIs: Software-generated form with substantially the same content as indicated above.
   1. Attachments shall be electronic files in Adobe Acrobat PDF format.

D. Engineer's Action: Engineer will review each RFI, determine action required, and return it. Allow seven calendar days for Engineer's response for each RFI. RFIs received after 1:00 p.m. local time will be considered as received the following working day.
   1. The following RFIs will be returned without action:
      a. Requests for approval of Submittals.
      b. Requests for approval of substitutions.
      c. Requests for coordination information already indicated in the Contract Documents.
      d. Requests for adjustments in the Contract Times or the Contract Price.
      e. Requests for interpretation of Engineer's actions on Submittals.
      f. Incomplete RFIs or RFIs with numerous errors.
   2. Multiple RFIs addressing similar or identical issues may be addressed by Engineer with a single broad response.
   3. Engineer's action may include a request for additional information, in which case Engineer's time for response will start again upon Contractor's response and resubmittal.
   4. If Contractor believes the RFI response warrants change in the Contract Times or the Contract Price, notify Engineer in writing within ten days of receipt of the RFI response. An RFI alone is not a Change Order and does not authorize cost/time changes.

E. On receipt of Engineer's action, update the RFI log and promptly distribute the RFI response to affected parties. Review response and notify Engineer within seven days if Contractor disagrees with response. This process does not toll or extend the requirements outlined in the GENERAL CONDITIONS and all Contract Price and Time requests must follow Articles IX and X of the GENERAL CONDITIONS.

F. RFI Log: Prepare, maintain, and submit a tabular log of RFIs organized by the RFI number. Submit log weekly. Electronic log with not less than the following:
   1. Project name.
   2. Name and address of Contractor.
   3. Contractor representative name and telephone number.
   4. Name and address of Engineer.
   5. RFI number including RFIs that were dropped and not submitted.
   6. RFI description.
   7. Date the RFI was submitted.
   8. Date Engineer's response was received.
   9. Identification of related Field Order, Work Change Directive, and Proposal Request, as appropriate.

SECTION 01 31 00 – PROJECT COORDINATION AND MEETINGS: continued

PART 2 - PRODUCTS - NOT APPLICABLE

PART 3 - EXECUTION - NOT APPLICABLE

END OF SECTION 01 31 00

SECTION 01 32 00 – CONSTRUCTION PROGRESS SCHEDULES AND REPORTS

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes administrative and procedural requirements for documenting the progress of construction during performance of the Work, including the following:
   1. Preliminary construction progress schedule.
   2. Construction progress schedule.
   3. Schedule of Submittals.
   4. Schedule of values.
   5. Construction progress reports.
   6. Daily construction reports.
   7. Equipment and Material location reports.
   8. Field condition reports.
   9. Special reports.

1.02 RELATED REQUIREMENTS:

A. For general schedule and report requirements: GENERAL CONDITIONS
B. For submitting and distributing meeting and conference minutes: Section 01 31 00 – "Project Coordination and Meetings."
C. For submitting schedules and reports: Section 01 33 00 – "Submittals."
D. For submitting construction photographs: Section 01 32 33 – "Construction Photographs"

1.03 REFERENCE STANDARDS:

A. Associated General Contractor's of America (AGC):
   1. Construction Planning and Scheduling.

1.04 DEFINITIONS:

A. Activity: A discrete part of a contract that can be identified for planning, scheduling, monitoring, and controlling the construction Work. Activities included in a construction schedule consume time and resources, but shall not include planned work stoppages. Activities shall not normally reflect the Work of more than one trade.
   1. Critical activities are activities on the critical path and have zero or negative float. Critical activities must start and finish on the planned early start and finish times.
   2. Predecessor Activity: An activity that precedes another activity in the network.
   3. Successor Activity: An activity that follows another activity in the network.
B. "Baseline" schedule: The schedule submitted and accepted by Engineer for the Work.
C. Cost Loading: The allocation of the schedule of values for the completion of an activity as scheduled. The sum of costs for all activities must equal the total Contract Price, unless otherwise approved by Engineer.
D. CPM: Critical path method (CPM), which is a method of planning and scheduling a construction contract where activities are arranged based on activity relationships. Network calculations determine when activities can be performed and the critical path of Contract.
E. Critical Path: The longest connected chain of interdependent activities through the network schedule that establishes the minimum overall Contract duration and contains no float.
F. Event: The starting or ending point of an activity. An event has no duration.
G. Float: The measure of leeway in starting and completing an activity.
   1. Float time is not for the exclusive use or benefit of either Owner or Contractor, but is a jointly owned, expiring Project resource available to both parties as needed to meet schedule milestones and Contract completion date.

2. Free float is the amount of time an activity can be delayed without adversely affecting the early start of the successor activity.
3. Total float is the measure of leeway in starting or completing an activity without adversely affecting an intermediate deadline or the planned Contract completion date.

H. Fragnet: A partial or fragmentary network that breaks down activities into smaller activities for greater detail.

I. Milestone: A key or critical point in time for reference or measurement. A milestone has no duration.

J. Network Diagram: A graphic diagram of a network schedule, showing activities and activity relationships.

K. Resource Loading: The allocation of manpower and equipment necessary for the completion of an activity as scheduled.

1.05 SUBMITTALS:

A. Schedule of Submittals: Submit in specified electronic format. Arrange the following information in a tabular format:
1. Scheduled date for first submittal.
2. Specification Section number and title.
3. Submittal category (technical or informational).
4. Name of Subcontractor or Supplier.
5. Description of the Work covered.
6. Scheduled date for Engineer's final release or approval.

B. Preliminary Construction Progress Schedule: Submit in specified electronic format.
1. Acceptance of cost-loaded preliminary construction schedule will not constitute acceptance of schedule of values for cost-loaded activities.

C. Preliminary Network Diagram: Submit initial schedule large enough to show entire network for entire construction period. Show logic ties for activities.

D. Construction Progress Schedule: Submit initial schedule, large enough to show entire schedule for entire construction period to Engineer for review and acceptance.
1. Submit electronically, using software indicated, labeled to comply with requirements for Submittals. Include type of schedule (Initial or Updated) and date.

E. Schedule of Values: Submit with initial construction progress schedule to Engineer for review and approval in specified electronic format.

F. Construction Progress Reports: Submit electronic copy with applications for payment.

G. Daily Construction Reports: Submit electronic copy on weekly intervals.

H. Field Condition Reports: Submit electronic Copy at time of discovery of differing conditions.

I. Special Reports: Submit electronic copy at time of unusual event.

J. Construction Photographs: Submit electronic copy with applications for payment.

1.06 COORDINATION:

A. Coordinate preparation and processing of schedules and reports with performance of construction activities and with scheduling and reporting of separate contractors.

B. Coordinate construction progress schedule with the schedule of values, list of subcontracts, schedule of Submittals, Material and Equipment procurement, progress reports, payment requests, and other required schedules and reports.
1. Secure time commitments for performing critical elements of the Work from parties involved.
2. Coordinate each construction activity in the network with other activities and schedule them in proper sequence.

1.07 COORDINATION:

A. Coordinate preparation and processing of schedules and reports with performance of construction activities and with scheduling and reporting of separate contractors.

B. Coordinate construction progress schedule with the schedule of values, list of subcontracts, schedule of Submittals, Material and Equipment procurement, progress reports, payment requests, and other required schedules and reports.

1. Secure time commitments for performing critical elements of the Work from parties involved.
2. Coordinate each construction activity in the network with other activities and schedule them in proper sequence.

PART 2 - PRODUCTS

2.01 SCHEDULE OF SUBMITTALS:

A. Preparation: Submit a schedule of Submittals, arranged in chronological order by dates required by construction progress schedule. Include time required for review, resubmittal, ordering, manufacturing, fabrication, and delivery when establishing dates as required in Section 01 33 00 – "Submittals."

1. Coordinate Submittals schedule with list of subcontracts, the schedule of values, and "Baseline" construction progress schedule.
2. Initial Submittal: Submit concurrently with preliminary CPM network diagram. Include Submittals required during the first 60 days of construction. List those required to maintain orderly progress of the Work and those required early because of long lead time for manufacture or fabrication.
3. Interim Submittals: Provide an updated submittal schedule monthly with the application for payment.
4. Final Submittal: Submit concurrently with the first complete submittal of construction progress schedule.

2.02 CONTRACTOR'S CONSTRUCTION PROGRESS SCHEDULE, GENERAL:

A. Time Frame: Extend schedule from date established in the Notice to Proceed to date of Final Completion.

1. Contract completion date shall not be changed by submission of a schedule that shows an early completion date, unless specifically authorized by Change Order.

B. Activities: Treat each building floor or separate area as a separate numbered activity for each principal element of the Work. Comply with the following:

1. Activity Duration: Define activities so no activity is longer than 30 calendar days, unless specifically allowed by Engineer.
2. Procurement Activities: Include procurement process activities for the following long lead items and major items, requiring a cycle of more than 60 days, as separate activities in schedule. Procurement cycle activities include, but are not limited to, Submittals, approvals, purchasing, fabrication, and delivery.
3. Submittal Review Time: Include review and resubmittal times indicated in Section 01 33 00 – "Submittals" in schedule. Coordinate Submittal review times in Contractor's construction progress schedule with schedule of Submittals.
4. Startup and Testing Time: Specified in Divisions 02 through 33.
5. Substantial Completion: Indicate completion in advance of date established for Substantial Completion and allow time for Engineer's administrative procedures necessary for certification of Substantial Completion.

C. Constraints: Include constraints and work restrictions indicated in the Contract Documents and as follows in schedule and show how the sequence of the Work is affected.
   1. Work Restrictions: Show the effect of the following items on the schedule:
      a. Coordination with existing construction.
      b. Limitations of continued occupancies.
      c. Uninterruptible services.
      d. Partial occupancy before Substantial Completion.
      e. Use of premises restrictions.
      f. Provisions for future construction.
      g. Seasonal variations.

D. Milestones: Include milestones indicated in the Contract Documents in schedule, including, but not limited to, the Notice to Proceed, Substantial Completion, and Final Completion.

E. Contract Modifications: For each proposed Contract modification and concurrent with its submission, prepare a time-impact analysis using fragnets to demonstrate the effect of the proposed change on the overall schedule.

2.03 PRELIMINARY CONSTRUCTION PROGRESS SCHEDULE:

A. Bar-Chart Schedule: Submit preliminary horizontal bar-chart-type construction schedule within seven days of date established in the Notice to Proceed.
   1. Preparation: Indicate each significant construction activity separately. Identify first workday of each week with a continuous vertical line. Outline significant construction activities for first 60 days of construction. Include skeleton diagram for the remainder of the Work.

B. Preliminary Schedule of Values:
   1. Initiate a preliminary value assigned to each significant construction activity.
   2. Values shall give an indication of cash requirement prediction, with total equal to Contract Price.
   3. Submit within ten days of Effective Date of Contract to Engineer and Owner for review.

2.04 CONSTRUCTION PROGRESS SCHEDULE (GANTT CHART):

A. Gantt-Chart Schedule: After submittal of preliminary construction progress schedule as stated above, submit a detailed construction progress schedule within 30 days after the Notice to Proceed. Base the schedule on the preliminary construction progress schedule and incorporate review comments and other feedback.

B. The schedule shall show the Work in a horizontal bar chart or other graphic format suitable for displaying scheduled and actual progress.
   1. The schedule shall indicate phases of the Work, starting date, interim milestones, and dates of Substantial Completion and Final Completion.
   2. Breakdown Work phases into separate time bar for each significant construction activity entry, with dates Work is expected to begin and be completed. Within each time bar, indicate estimated completion percentage in 10% increments.
   3. Scale and spacing shall allow room for notation and revisions.
   4. Sheet Size: Minimum 11 x 17 inches.

C. Provide subschedules to define in more detail critical portions of schedules, including inspections and tests.

D. Coordinate construction progress schedule with schedule of values, schedule of Submittals schedule, procurement schedule, progress reports, and payment requests.

E. Engineer will review and comment on construction progress schedule and, upon agreement between Engineer and Contractor on necessary changes:

1. Contractor shall distribute copies as specified of the accepted "baseline" schedule to Engineer. Contractor shall provide additional copies to Subcontractors and other parties required to comply with scheduled dates, one copy to each party.

F. Revise the construction progress schedule with each Application for Payment, and/or after each meeting, event, or activity where revisions have been recognized and accepted to reflect impacts of new developments on the schedule.

G. Update and submit electronic copy to Engineer of the revised schedule at least once each month to show actual progress compared to the originally accepted "baseline" schedule and any proposed changes in the schedule of remaining Work. Include with construction progress report.

2.05 SCHEDULE OF VALUES:

A. Based on the preliminary draft schedule of values, reviewed by Engineer and Owner, submit finalized schedule of values acceptable to Engineer as to form and basic details. Submit final within 30 days after Notice to Proceed.

B. Coordinate preparation of schedule of values with preparation and content of construction progress schedule.

C. Content:

1. Schedule shall list the installed value of the component parts of the Work in sufficient detail to serve as a basis for computing values for progress payments during construction.
2. Follow the table of contents of this Project Manual as the format for listing component items.
    a. Identify each line item, with the number and title of the respective major Division or Section of the Specifications.
3. For each major line item, list subvalues of major products or operations under the item.
    a. Each item shall include a directly proportional amount of the Contractor's overhead and profit.
    b. For items on which progress payments will be requested for stored materials received, but not installed, break down the value into:
        (1) The cost of the materials, delivered and unloaded, including taxes paid unless taxes are exempted.
        (2) The total installed value.
    c. The sum of all values listed in the schedule shall equal the total Contract Price.

2.06 REPORTS:

A. Construction Progress Reports:

1. Submit a report on actual construction progress on a weekly basis. More frequent reports may be required should the Work fall behind the accepted schedule.
    a. Submit a weekly report (and three-week look-ahead schedule) to coordinate with and supplement the monthly construction progress report and which details Work scheduled for the following one-week interval, including:
        (1) Work activities which will occur.
        (2) Number and size of crews.
        (3) Construction equipment on Site.
        (4) Major items of Equipment and Material to be installed.
    b. Reports shall be submitted to Engineer in electronic format.
2. Construction progress reports shall consist of the revised construction progress schedule and a narrative report which shall include but not be limited to the following:

a. Comparison of actual progress to planned progress shown on originally accepted schedule.
b. Summary of activities completed since the previous construction progress report.
c. Summary of activities planned for next reporting period.
d. Planned, earned, and spent earned value analysis for the month.
e. Identification of problem areas.
f. A description of current and anticipated delaying factors, if any.
g. Impact of possible delaying factors.
h. Proposed corrective actions.
i. Construction progress photographs.

3. Submit a construction progress report to Engineer with each application for partial payment. Work reported complete but not readily apparent to Engineer must be substantiated with supporting data when requested by Engineer.
4. If a schedule update reveals that, through no fault of Owner, the Work is likely to be completed later than the Contract completion date, Contractor shall:
   a. Establish a plan for making up lost time.
   b. Submit plan to Owner and Engineer before implementing the plan.
   c. Take actions as necessary to get the Work back on schedule at no additional cost to Owner.

B. Weekly Construction Reports: Prepare a weekly construction report recording the following information concerning events at Project Site:
1. List of Subcontractors at Project Site.
2. List of separate contractors at Project Site.
3. Approximate count of personnel at Project Site, and breakdown by craft.
4. Equipment at Project Site.
5. Material deliveries.
6. High and low temperatures and general weather conditions.
7. Accidents.
8. Meetings and significant decisions.
9. Unusual events (refer to special reports).
10. Types of Work and locations
11. Hours worked on each activity
12. Damage to in-place work
13. Test reports
14. Standard Work Days not worked
15. Stoppages, delays, shortages, and losses.
16. Meter readings and similar recordings.
17. Emergency procedures.

C. Equipment and Material Location Reports: At monthly intervals, prepare and submit a comprehensive list of Equipment and Materials delivered to and stored at Project Site. List shall be cumulative, showing Equipment and Materials previously reported plus items recently delivered. Include with list a statement of progress on and delivery dates for Materials or items of Equipment fabricated or stored away from Project Site.

D. Field Condition Reports: Promptly on discovery of a difference between field conditions and the Contract Documents, prepare and submit a detailed report. Submit with a request for information (RFI). Include a detailed description of the differing conditions, together with recommendations for changing the Contract Documents.

E. Special Reports:

1. General: Submit special reports directly to Owner within one day of an occurrence. Distribute copies of report to parties affected by the occurrence.
2. Reporting Unusual Events: When an event of an unusual and significant nature occurs at Project Site, whether or not related directly to the Work, prepare and submit a special report. List chain of events, persons participating, response by Contractor's personnel, evaluation of results or effects, and similar pertinent information. Advise Owner in advance when these events are known or predictable.

PART 3 - EXECUTION

3.01 CONSTRUCTION PROGRESS SCHEDULE:

A. Construction Progress Schedule Updating: At weekly intervals, update schedule to reflect actual construction progress and activities. Issue schedule two days before each regularly scheduled construction progress meeting.
   1. Revise schedule immediately after each meeting or other activity where revisions have been recognized or made. Issue updated schedule concurrently with the report of each such meeting.
   2. Include a report with updated schedule that indicates every change, including, but not limited to, changes in logic, durations, actual starts and finishes, and activity durations.
   3. As the Work progresses, indicate actual completion percentage for each activity.

B. Distribution: Distribute copies of accepted schedule to Engineer, Owner, separate contractors, testing and inspecting agencies, and other parties identified by Contractor with a need-to-know schedule responsibility.
   1. Post copies in Project meeting rooms and temporary field offices.
   2. When revisions are made, distribute updated schedules to the same parties and post in the same locations. Delete parties from distribution when they have completed their assigned portion of the Work and are no longer involved in performance of construction activities.

END OF SECTION 01 32 00

SECTION 01 32 33 – CONSTRUCTION PHOTOGRAPHS

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section specifies administrative and procedural requirements for construction photographs.

1.02 SUBMITTALS:

A. Submit prints as specified in Section 01 33 00 – "Submittals" and in PART 3 - this Section.

1.03 QUALITY ASSURANCE:

A. All photographs shall be taken by a qualified individual with experience in construction photography.

PART 2 - PRODUCTS

2.01 PHOTOGRAPHIC REQUIREMENTS: SPECIFIED IN PART 3, THIS SECTION.

PART 3 - EXECUTION

3.01 PROGRESS SITE PHOTOGRAPHS:

A. Contractor shall be responsible for photographs of the Site to show the existing and general progress of the Work. Engineer will advise as to which views are of interest. Photographs shall be taken of the following areas and at the following times.
   1. Existing Site conditions before Site work is started. Number of views shall be adequate to cover the Site.
   2. Progress of the Work from clearing throughout construction. There shall be five different views taken on or about the first of each month.
   3. Finished Project after completion of Work. Number of views shall be adequate to show the finished Work.
   4. If Project is not completed during the Contract Time or authorized extensions, photographs shall continue to be taken at no increase in Contract Price.

B. Contractor shall take a drone image of the construction site during critical time periods, but no less than once a month. Contractor shall take a minimum of 5 different views and shall use the same views from month to month, to show construction progress.

C. Digital Images:
   1. Submit a complete set of digital image electronic files as a Project record document.
      a. Provide images in JPEG format, with minimum sensor size of 12.0 megapixels.
      b. Provide image resolution of not less than 300 dpi.
      c. Submit images that have same aspect ratio as the sensor, uncropped.

D. Identification:
   1. Identify electronic media with date digital photographs were taken.

E. Submit electronic media files monthly to the Engineer and Owner with application for payment.

3.02 ADDITIONAL PHOTOGRAPHS:

A. From time to time, Engineer may issue requests for additional photographs, in addition to periodic photographs specified. Additional photographs shall be provided at no cost to the Owner.

1. Engineer will give the photographer three days' notice, where feasible.
2. In emergency situations, the photographer shall take additional photographs within 24 hours of Engineer's request.
3. Circumstances that could require additional photographs include, but are not limited to:
    a. Substantial Completion of a major phase or component of Work.
    b. Owner's request for special publicity photographs.
    c. Special events planned at Project Site.
    d. Immediate follow-up when on-site events result in construction damage or losses.
    e. Photographs to be taken at fabrication locations away from Project Site.
    f. Extra record photographs at time of final acceptance.

END OF SECTION 01 32 33

SECTION 01 33 00 – SUBMITTALS

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes definitions, descriptions, transmittal, and review of Submittals.

1.02 RELATED REQUIREMENTS:

A. Section 01 31 00 – "Construction Progress Schedules and Reports."
B. Section 01 32 33 – "Construction Photographs."
C. Section 01 78 00 – "Contract Closeout."

1.03 GENERAL INFORMATION:

A. Definitions:
   1. Shop Drawings, product data, and Samples are technical Submittals prepared by Contractor, Subcontractor, manufacturer, or Supplier and submitted by Contractor to Engineer as a basis for approval of the use of Equipment and Materials proposed for incorporation in the Work or needed to describe installation, operation, maintenance, or technical properties, as specified in each Division of the Specifications.
      a. Shop Drawings include custom-prepared data of all types including drawings, diagrams, performance curves, material schedules, templates, instructions, and similar information not in standard printed form applicable to other projects.
      b. Product data includes standard printed information on materials, products, and systems; not custom-prepared for this Project, other than the designation of selections from available choices.
      c. Samples include both fabricated and unfabricated physical examples of materials, products, and Work; both as complete units and as smaller portions of units of Work; either for limited visual inspection or (where indicated) for more detailed testing and analysis. Mock-ups are a special form of Samples which are too large to be handled in the specified manner for transmittal of Sample Submittals.
      d. Descriptions of submittal requirements (as applicable) are defined in Appendix B – Submittal Descriptions.
   2. Informational Submittals are those technical reports, administrative Submittals, certificates, and guarantees not defined as Shop Drawings, product data, or Samples.
      a. Technical reports include laboratory reports, tests, technical procedures, technical records, and Contractor's design analysis.
      b. Administrative Submittals are those nontechnical Submittals required by the Contract Documents or deemed necessary for administrative records. These Submittals include maintenance agreements, Bonds, Project photographs, physical work records, statements of applicability, copies of industry standards, Project record data, schedules, security/protection/safety data, and similar type Submittals.
      c. Certificates and guarantees are those Submittals on Equipment and Materials where a written certificate or guarantee from the manufacturer or Supplier is called for in the Specifications.
   3. Refer to ARTICLES 1.03 and 1.04 of this Part for detailed lists of Submittals and specific requirements.
B. Quality Requirements:
   1. Submittals such as Shop Drawings and product data shall be of suitable quality for legibility and reproduction purposes. Every line, character, and letter shall be clearly legible. Drawings such as reproducible shall be useable for further reproduction to yield legible hard copy.

2. Documents submitted to Engineer that do not conform to specified requirements shall be subject to rejection by Engineer, and upon request by Engineer, Contractor shall resubmit conforming documents. If conforming Submittals cannot be obtained, such documents shall be retraced, redrawn, or photographically restored as may be necessary to meet such requirements. Contractor's or his Subcontractor's failure to initially satisfy the legibility quality requirements will not relieve Contractor or his Subcontractors from meeting the required schedule for Submittals.

C. Language and Dimensions:
   1. All words and dimensional units shall be in the English language.
   2. Metric dimensional unit equivalents may be stated in addition to the English units. However, English units of measurement shall prevail.

D. Submittal Completeness:
   1. Submittals shall be complete with respect to dimensions, design criteria, materials of construction, and other information specified to enable Engineer to review the information effectively.
   2. Where standard drawings are furnished which cover a number of variations of the general class of Equipment, each drawing shall be annotated to indicate exactly which parts of the drawing apply to the Equipment being furnished. Use hatch marks to indicate variations that do not apply to the Submittal. The use of "highlighting markers" will not be an acceptable means of annotating Submittals. Annotation shall also include proper identification of the Submittal permanently attached to the drawing.
   3. Reproductions or copies of Contract Drawings or portions thereof will not be accepted as complete fabrication or erection drawings. Contractor may use a reproduction of Contract Drawings for erection drawings to indicate information on erection or to identify detail drawing references. Whenever the Drawings are revised to show this additional Contractor information, Engineer's title block shall be replaced with Contractor's title block, and Engineer's professional seal shall be removed from the drawing. Contractor shall revise these erection drawings for subsequent Engineer revisions to the Contract Drawings.

E. Form of Submittals:
   1. Submittals and other Project documents shall be transmitted in electronic format as specified.
      a. Selected Submittals may be provided in paper ("hardcopy") copies only with advance approval of Engineer, and using procedures specified herein.
      b. Equipment instruction books and operating manuals shall be provided in paper copies in addition to specified electronic format.
   2. Electronic Format:
      a. Scanned Submittals and documents are not acceptable. Transmit Submittals and Project documents in:
         (1) Nonproprietary, native electronic format incorporating any necessary reference files, or
         (2) Adobe *PDF files created directly from native electronic format, or
         (3) Engineer-approved equal.
         (4) Electronic submittal PDF files are not to be combined files or collections of files/drawings. Each drawing document must stand alone.
         (5) Each file will be right reading and orientation the same for all consecutive resubmissions.
         (6) For any given Submittal, the filename and format shall be consistent for initial submission and subsequent revisions of the same. Use consistent naming

convention throughout. Reference to revision or dates shall not be included in a filename.

(7) Nonconforming Submittals are subject to rejection by Engineer.

b. Provide "as-constructed" Submittals, record documents, Equipment instruction books and operating manuals, and other documents in Adobe *PDF format as required and approved by Owner.

c. Equipment instruction books and operating and maintenance manuals shall be in Adobe *PDF format combined in one pdf file for the complete O&M manual or divided into pdf files that represent entire volumes (corresponding to hardcopy volumes). The pdf files shall be completely bookmarked with links within the index sheet to the different sections within the manuals/volumes, corresponding to the defined tabs within the hardcopy version.

(1) Digital delivery media shall be to a Dropbox or OneDrive site set up by the City.

1.04 TECHNICAL SUBMITTALS:

A. Items shall include, but not be limited to, the following:

1. Manufacturer's specifications.
2. Catalogs, or parts thereof, of manufactured Equipment.
3. Shop fabrication and erection drawings.
4. General outline drawings of Equipment showing overall dimensions, location of major components, weights, and location of required building openings and floor plates.
5. Detailed Equipment installation drawings, showing foundation details, anchor bolt sizes and locations, baseplate sizes, location of Owner's connections; and all clearances required for erection, operation, and disassembly for maintenance.
6. Schematic diagrams for electrical items, showing external connections, terminal block numbers, internal wiring diagrams and one-line diagrams.
7. Bills of material and spare parts list.
8. Instruction books and operating manuals.
9. Material lists or schedules.
10. Performance tests on Equipment by manufacturers.
11. Concrete mix design information.
12. Samples and color charts.
13. All drawings, catalogs or parts thereof, manufacturer's specifications and data, Samples, instructions, and other information specified or necessary:
    a. For Engineer to determine that Equipment and Materials conform to the design concept and comply with intent of the Contract Documents.
    b. For proper erection, installation, operation, and maintenance of Equipment and Materials which Engineer will review for general content but not for basic details.
    c. For Engineer to determine what supports, anchorages, structural details, connections, and services are required for Equipment and Materials, and effects on contiguous or related structures and Equipment and Materials.

B. Schedule of Submittals:

1. Prepare for Engineer's concurrence, a schedule for submission of all Submittals specified or necessary for Engineer's approval of the use of Equipment and Materials proposed for incorporation in the Work or needed for proper installation, operation, or maintenance. Submit the schedule with the procurement schedule and construction progress schedule. Schedule submission of all Submittals to permit review, fabrication, and delivery in time

so as to not cause a delay in the Work of Contractor or his Subcontractors or any other contractors as described in the Contract Documents.

2. In establishing schedule for Submittals, allow 20 calendar days for reviewing original Submittals and 15 calendar days in for reviewing resubmittals.
3. Submittals requiring revision shall be resubmitted within 15 calendar days after receipt of Engineer's review notations.
4. The schedule shall indicate the anticipated dates of original submission for each item and Engineer's approval thereof and shall be based upon at least one resubmission of each item.
5. Schedule all Submittals (Shop Drawings, product data, and Samples) required prior to fabrication or manufacture for submission within 90 days of the Notice to Proceed. Schedule Submittals pertaining to storage, installation, and operation at the Site for Engineer's approval prior to delivery of the Equipment and Materials. If 90 days cannot be met, notify Engineer in writing with a suggested timeframe.
6. Resubmit Submittals the number of times required for Engineer's "Submittal Approved." However, any need for resubmittals in excess of the number set forth in the accepted schedule, or any other delay in obtaining approval of Submittals, will not be grounds for extension of the Contract Times, provided Engineer completes his reviews within the times specified.
7. Where a Submittal is required by the Contract Documents or the accepted schedule of Submittals, any related Work performed prior to Engineer's review and approval of the pertaining Submittal will be at the sole expense and responsibility of Contractor.

C. Transmittal of Submittals:

1. All Submittals (Shop Drawings, product data, and Samples) for Equipment and Materials furnished by Contractor, Subcontractors, manufacturers, and Suppliers shall be submitted to Engineer by Contractor.
2. After checking and verifying all field measurements, transmit all Submittals to Engineer for approval as follows:
    a. Submittal Information Block:
        (1) Affix to all paper copies whether Submittal is prepared by Contractor, Subcontractor, or Supplier. Use transparent decal type Submittal Information Blocks for Shop Drawings and use gummed paper type for product data and Sample Submittals. All Submittal Information Blocks needed for this Contract will be furnished to Contractor at no charge at the initial coordination conference.
    b. Mark each Submittal by Project name and number, Contract title and number, and applicable Specification Section and Article number. Include in the letter of transmittal the Drawing number and title, sheet number (if applicable), revision number, and electronic filename (if applicable). Unidentifiable Submittals will be returned for proper identification.
    c. Check and approve Submittals of Subcontractors, Suppliers, and manufacturers prior to transmitting them to Engineer. Contractor's submission shall constitute a representation to Owner and Engineer that Contractor approves Submittals and has determined and verified all design criteria, quantities, dimensions, field construction and installation criteria, materials, catalog numbers, compliance with Laws and Regulations, and similar data, and Contractor assumes full responsibility for doing so; and Contractor has coordinated each Submittal with the requirements of the Work and the Contract Documents.

d. At the time of each submission, call to the attention of Engineer in the letter of transmittal any deviations from requirements of the Contract Documents.
e. Make all modifications noted or indicated by Engineer and return the required number of revised Submittals until approved. Direct specific attention in writing, or on revised Submittals, to changes other than the modifications called for by Engineer on previous Submittals. After paper copy Submittals have been approved, submit copies thereof for final distribution. Previously approved Submittals transmitted for final distribution will not be further reviewed and are not to be revised. If errors are discovered during manufacture or fabrication, correct the Submittal and resubmit for review.
f. Following completion of the Work and prior to final payment, furnish record documents and approved Samples and Shop Drawings necessary to indicate "as constructed" conditions, including field modifications, in the number of copies specified. Furnish additional copies for insertion in Equipment instruction books and operating manuals as required. All such copies shall be clearly marked "PROJECT RECORD."
    (1) Submit a final record copy of the Master Field Drawing list which shall indicate the final revision status of each drawing on the list.
g. Keep a copy or sample of each Submittal in good order at the Site.

3. Quantity Requirements:
    a. Except as otherwise specified, transmit all Shop Drawings in the following quantities:
        (1) Initial Submittal:
            (a) Electronic - One copy to Engineer and Owner.
        (2) Resubmittals:
            (a) Electronic - One copy to Engineer and Owner.
        (3) Submittal for final distribution:
            (a) Electronic - One copy to Engineer and Owner.
        (4) As-constructed documents:
            (a) Electronic - One copy to Engineer and Owner.
    b. Transmit Submittals of product data as follows:
        (1) Initial Submittal:
            (a) Electronic - One copy to Engineer and Owner.
        (2) Resubmittals:
            (a) Electronic - One copy to Engineer and Owner.
        (3) Submittal for final distribution:
            (a) Paper – 2 copies plus the number of copies required by Contractor, to Engineer.
            (b) Electronic - One copy to Engineer and Owner.
    c. Transmit Submittals of Material Samples, color charts, and similar items as follows:
        (1) Initial Submittal – 3 to Engineer.
        (2) Resubmittal – 3 to Engineer.
        (3) Upon approval, 1 Sample(s) will be returned to Contractor.
    d. Transmit Submittals of Equipment instruction books and operating manuals as follows:
        (1) Initial Submittal:
            (a) Electronic - One copy to Engineer. One copy to Owner.
        (2) Resubmittals:
            (a) Electronic - One copy to Engineer. One copy to Owner.

(3) Submittal for Final Distribution –
(a) 4 paper copies to Engineer.
(b) 1 electronic copy to Owner and Engineer.

e. When all Submittals have been updated to "as-constructed" conditions, transmit to Engineer and to Owner in electronic format.

f. Owner may copy and use for internal operations and staff training purposes any and all document Submittals required by this Contract and approved for final distribution, whether or not such documents are copyrighted, at no additional cost to Owner. If permission to copy any such Submittal for the purposes stated is unreasonably withheld from Owner by Contractor or any Subcontractor, manufacturer, or Supplier, Contractor shall provide to Engineer 15 copies plus the number of copies required by Contractor at each final distribution issue.

D. Engineer's Review:

1. Engineer will review and take appropriate action on Submittals in accordance with the accepted schedule of Submittals. Engineer's review and approval will be only to determine if the items of Equipment and Materials covered by the Submittals will, after installation or incorporation in the Work, conform to information given in the Contract Documents and be compatible with the design concept of the completed Project as a functioning whole as indicated by the Contract Documents.
2. Engineer's review and approval will not extend to design data reflected in Submittals which is peculiarly within the special expertise of Contractor or Contractor's Subcontractors or Suppliers. Review and approval of a component item as such will not indicate approval of the assembly in which the item functions.
3. Engineer's review and approval of Shop Drawings, product data, or Samples will not relieve Contractor of responsibility for any deviation from requirements of the Contract Documents unless Contractor has in writing called Engineer's attention to such deviation at the time of submission, and Engineer has given written concurrence in and approval of the specific deviation. Approval by Engineer shall not relieve Contractor from responsibility for errors or omissions in Submittals.

E. Submittal Action Stamp:

1. Engineer's review action stamp, appropriately completed, will appear on all Submittals of Contractor when returned by Engineer. Review status designations listed on Engineer's action stamp are defined as follows:

A - SUBMITTAL APPROVED: Signifies Equipment or Material represented by the Submittal conforms with the design concept and complies with the intent of the Contract Documents and is approved for incorporation in the Work. Contractor is to proceed with fabrication or procurement of the items and with related Work. Copies of the Submittal are to be transmitted to Engineer for final distribution.

B - SUBMITTAL APPROVED AS NOTED (RESUBMIT): Signifies Equipment and Material represented by the Submittal conforms with the design concept and complies with the intent of the Contract Documents and is approved for incorporation in the Work in accordance with Engineer's notations. Contractor is to proceed with fabrication or procurement of the items and with related Work in accordance with Engineer's notations and is to submit a revised Submittal responsive to notations marked on the returned Submittal or written in the letter of transmittal.

C - SUBMITTAL RETURNED FOR REVISION (RESUBMIT): Signifies Equipment and Material represented by the Submittal appears to conform with the design concept and comply with the intent of the Contract Documents, but information is either insufficient in detail or contains discrepancies which prevent Engineer from completing his review. Contractor is to resubmit revised information responsive to Engineer's annotations on the returned Submittal or written in the letter of transmittal. Fabrication or procurement of items represented by the Submittal and related Work is not to proceed until the Submittal is approved.

D - SUBMITTAL NOT APPROVED (SUBMIT ANEW): Signifies Equipment and Material represented by the Submittal does not conform with the design concept or comply with the intent of the Contract Documents and is disapproved for use in the Work. Contractor is to provide Submittals responsive to the Contract Documents.

E - PRELIMINARY SUBMITTAL: Signifies Submittals of such preliminary nature that a determination of conformance with the design concept or compliance with the intent of the Contract Documents must be deferred until additional information is furnished. Contractor is to submit such additional information to permit layout and related activities to proceed.

F - FOR REFERENCE, NO APPROVAL REQUIRED: Signifies Submittals which are for supplementary information only; pamphlets, general information sheets, catalog cuts, standard sheets, bulletins and similar data, all of which are useful to Engineer or Owner in design, operation, or maintenance, but which by their nature do not constitute a basis for determining that items represented thereby conform with the design concept or comply with the intent of the Contract Documents. Engineer reviews such Submittals for general content but not for basic details.

G - DISTRIBUTION COPY (PREVIOUSLY APPROVED): Signifies Submittals which have been previously approved and are being distributed to Contractor, Owner, Resident Project Representative, and others for coordination and construction purposes.

F. Instruction Books and Operating Manuals:
   1. In addition to electronic Submittals specified above, Equipment instruction books and operating manuals prepared by the manufacturer shall include the following:
      a. Index and tabs.
         (1) Electronic copies shall include bookmarks at a minimum of all tab locations.
      b. Instructions for installation, start-up, operation, inspection, maintenance, parts lists and recommended spare parts, and data sheets showing model numbers.
      c. Applicable drawings.
      d. Warranties and guarantees.
      e. Address of nearest manufacturer-authorized service facility.
      f. All additional data specified.
   2. Information listed above shall be bound into hard-back binders of three-ring type. Sheet size shall be 8-1/2 x 11. Binder color shall be black. Capacity shall be a minimum of 1-1/2 inches, but sufficient to contain and use sheets with ease. Four (4) sets of hardcopies and one (1) electronic set shall be furnished to Owner.
      a. Provide the following accessories:
         (1) Label holder.

(2) Business card holder.
(3) Sheet lifters.
(4) Horizontal pockets.

b. The following information shall be imprinted, inserted, or affixed by label on the binder front cover:
(1) Owner's name.
(2) Owner's facility or plant name.
(3) Equipment item name.
(4) Volume number (if applicable).
(5) Contract number.
(6) Manufacturer's name and address.

c. The following information shall be imprinted, inserted, or affixed by label on the binder spine:
(1) Equipment item name.
(2) Owner's name and Owner's facility or plant name.
(3) Manufacturer's name.
(4) Contract number.
(5) Volume number (if applicable).

d. Frequently referenced pages shall be inserted with plastic sleeves or laminated.

e. All final O&M manuals are furnished to the Owner as a condition to Initial Acceptance.

f. Submit mockup of cover and spine for Engineer's review.

G. Samples:
1. Office Samples shall be of sufficient size and quantity to clearly illustrate the following:
a. Functional characteristics of the product, with integrally related parts and attachment devices.
b. Full range of color, texture, and pattern.
c. Material, manufacturer, pertinent catalog number, and intended use.

1.05 INFORMATIONAL SUBMITTALS:

A. Informational Submittals are comprised of technical reports, administrative Submittals, and guarantees which relate to the Work, but do not require Engineer approval prior to proceeding with the Work. Informational Submittals include:
1. Field test reports.
2. Shipping or packing lists.
3. Job progress schedules.
4. Equipment and Material delivery schedules.
5. Progress photographs.
6. Warranties and guarantees.

B. Transmittal of Informational Submittals:
1. All informational Submittals furnished by Subcontractors, manufacturers, and Suppliers shall be submitted to Engineer by Contractor unless otherwise specified.
a. Identify each informational Submittal by Project name and number, Contract title and number, and Specification Section and Article number marked thereon or in letter of transmittal. Unidentifiable Submittals will be returned for proper identification.
b. At the time of each submission, call to the attention of Engineer in the letter of transmittal any deviations from requirements of the Contract Documents.
2. Quantity Requirements:

a. Technical reports and administrative Submittals except as otherwise specified:
(1) Electronic: One to Engineer.
b. Written Certificates and Guarantees:
(1) Engineer: 4 copies.

3. Test Reports:
a. Responsibilities of Contractor, Owner, and Engineer regarding tests and inspections of Equipment and Materials and completed Work are set forth elsewhere in these Contract Documents.
b. The party specified responsible for testing or inspection shall in each case, unless otherwise specified, arrange for the testing laboratory or reporting agency to distribute test reports as follows:
(1) Owner: 1 electronic copy.
(2) Engineer: 1 electronic copy.
(3) Contractor: As required by Contractor.
(4) Manufacturer or Supplier: 1 electronic copy.

C. Engineer's Review:
1. Engineer will review informational Submittals for indications of Work or Material deficiencies.
2. Engineer will respond to Contractor on those informational Submittals which indicate Work or Material deficiency.

PART 2 - EXECUTION - NOT APPLICABLE.

PART 3 - EXECUTION - NOT APPLICABLE.

END OF SECTION 01 33 00

SECTION 01 40 00 – CONTRACTOR QA/QC

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes administrative and procedural requirements for quality assurance and quality control.

B. Testing and inspecting services are required to verify compliance with requirements specified or indicated. These services do not relieve Contractor of responsibility for compliance with the Contract Document requirements.

1. Specific quality assurance and quality control requirements for individual construction activities are specified in the Sections that specify those activities. Requirements in those Sections may also cover production of standard products.
2. Specified tests, inspections, and related actions do not limit Contractor's other quality assurance and quality control procedures that facilitate compliance with the Contract Document requirements.
3. Requirements for Contractor to provide quality assurance and quality control services required by Engineer, Owner, or authorities having jurisdiction are not limited by provisions of this Section.

1.02 RELATED REQUIREMENTS:

A. For developing a schedule of required tests and inspections: Section 01 32 00 – "Construction Progress Schedules and Reports."

B. For required field services provided by manufacturers: Section 01 75 00 – “Manufacturer's Field Services.”

C. For specific test and inspection requirements: DIVISIONS 02 through 33 sections.

1.03 REFERENCE STANDARDS:

A. Publication Dates: Comply with standards in effect as of date of the IFC Contract Documents unless otherwise indicated.

B. ASTM International (ASTM):

1. E548 - Guide for General Criteria Used for Evaluating Laboratory Competence.

C. Code of Federal Regulations (CFR):

1. 29 CFR 1910, Subpart A, Section 1910.7 - Definition and Requirements for a Nationally Recognized Testing Laboratory (NRTL).

1.04 DEFINITIONS:

A. Quality Assurance Services: Activities, actions, and procedures performed before and during execution of the Work to guard against defects and deficiencies and substantiate that proposed construction will comply with requirements.

B. Quality Control Services: Tests, inspections, procedures, and related actions during and after execution of the Work to evaluate that actual Equipment and Materials incorporated into the Work and completed construction comply with requirements. Services do not include Contract enforcement activities performed by Engineer.

C. Mockups: Full-size, physical assemblies that are constructed on Site. Mockups are used to verify selections made under Sample Submittals, to demonstrate aesthetic effects and, where indicated, qualities of materials and execution, and to review construction, coordination, testing, or operation; they are not Samples. Approved mockups establish the standard by which the Work will be judged.

D. Laboratory Mockups: Full-size, physical assemblies that are constructed at testing facility to verify performance characteristics.

E. Preconstruction Testing: Tests and inspections that are performed specifically for the Project before Equipment and Materials are incorporated into the Work to verify performance or compliance with specified criteria.
F. Product Testing: Tests and inspections that are performed by an NRTL, an NVLAP, or a testing agency qualified to conduct product testing and acceptable to authorities having jurisdiction, to establish product performance and compliance with industry standards.
G. Source Quality Control Testing: Tests and inspections that are performed at the source, i.e., plant, mill, factory, or shop.
H. Field Quality Control Testing: Tests and inspections that are performed on Site for installation of the Work and for completed Work, i.e., soil compaction, concrete strength, and weld radiographs.
I. Testing Agency: An entity engaged to perform specific tests, inspections, or both. Testing laboratory shall mean the same as testing agency.
J. Installer/Applicator/Erector: Contractor or another entity engaged by Contractor as an employee, Subcontractor, or Sub-subcontractor, to perform a particular construction operation, including installation, erection, application, and similar operations.
K. Experienced: When used with an entity, "experienced" means having successfully completed a minimum of five previous projects similar in size and scope to this Project; being familiar with special requirements indicated; and having complied with requirements of authorities having jurisdiction.

1.05 SUBMITTALS:

A. Contractor with prime responsibility shall assume responsibility for all Compliance Submittals.
B. Qualification Data: For testing agencies specified in "Quality Control" Article to demonstrate their capabilities and experience. Include proof of qualifications in the form of a recent report on the inspection of the testing agency by a recognized authority.
C. Schedule of Tests and Inspections: Prepare in tabular form and include the following:
    1. Specification Section number and title.
    2. Description of test and inspection.
    3. Identification of applicable standards.
    4. Identification of test and inspection methods.
    5. Number of tests and inspections required.
    6. Time schedule or time span for tests and inspections.
    7. Entity responsible for performing tests and inspections.
    8. Requirements for obtaining samples.
    9. Unique characteristics of each quality control service.
D. Reports: Arrange for testing agency/laboratory to prepare and submit certified written reports that include the following:
    1. Date of issue.
    2. Project title and number.
    3. Name, address, and telephone number of testing agency.
    4. Dates and locations of samples and tests or inspections.
    5. Names of individuals making tests and inspections.
    6. Description of the Work and test and inspection method.
    7. Identification of product and Specification Section.
    8. Complete test or inspection data.
    9. Test and inspection results and an interpretation of test results.
    10. Record of temperature and weather conditions at time of sample taking and testing and inspecting.

11. Comments or professional opinion on whether tested or inspected Work complies with the Contract Document requirements.
12. Name and signature of laboratory inspector.
13. Recommendations on retesting and re-inspecting.

E. Permits, Licenses, and Certificates: For Owner's records, submit copies of permits, licenses, certifications, inspection reports, releases, jurisdictional settlements, notices, receipts for fee payments, judgments, correspondence, records, and similar documents, established for compliance with standards and regulations bearing on performance of the Work.

1.06 QUALITY CONTROL:

A. General: Qualifications paragraphs in this Article establish the minimum qualification levels required; individual Specification Sections specify additional requirements.

B. Installer Qualifications: A firm or individual experienced in installing, erecting, or assembling work similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance.

C. Manufacturer Qualifications: A firm experienced in manufacturing Equipment or systems or Material similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.

D. Fabricator Qualifications: A firm experienced in producing Equipment and Material similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.

E. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of the system, assembly, Equipment, or Material that are similar to those indicated for this Project in material, design, and extent.

F. Specialists: Certain sections of the Specifications require that specific construction activities shall be performed by entities who are recognized experts in those operations. Specialists shall satisfy qualification requirements indicated and shall be engaged for the activities indicated.
1. Requirement for specialists shall not supersede building codes and regulations governing the Work.

G. Testing Agency Qualifications: An NRTL, an NVLAP, or an independent agency with the experience and capability to conduct testing and inspecting indicated, as documented according to ASTM E548; and with additional qualifications specified in individual Sections; and where required by authorities having jurisdiction, that is acceptable to authorities.
1. NRTL: A nationally recognized testing laboratory according to 29 CFR 1910.7.
2. NVLAP: A testing agency accredited according to NIST's National Voluntary Laboratory Accreditation Program (NVLAP).

H. Factory-Authorized Service Representative Qualifications: An authorized representative of manufacturer who is trained and approved by manufacturer to inspect installation of manufacturer's Equipment, Material, or systems that are similar in material, design, and extent to those indicated for this Project.

I. Preconstruction Testing: Where testing agency is indicated to perform preconstruction testing for compliance with specified requirements for performance and test methods, comply with the following:
1. Contractor responsibilities include the following:
a. Provide test specimens representative of proposed products and construction.
b. Submit specimens in a timely manner with sufficient time for testing and analyzing results to prevent delaying the Work.

c. Provide sizes and configurations of test assemblies, mockups, and laboratory mockups to adequately demonstrate capability of products to comply with performance requirements.
d. When testing is complete, remove test specimens, assemblies, mockups, and laboratory mockups; do not reuse products on Project.

2. Testing Agency Responsibilities: Submit a certified written report of each test, inspection, and similar quality-assurance service to Engineer, with copy to Contractor. Interpret tests and inspections and state in each report whether tested and inspected work complies with or deviates from the Contract Documents.

J. Tests and inspections not explicitly assigned to Owner are Contractor's responsibility. Unless otherwise indicated, provide quality control services specified and those required by authorities having jurisdiction. Perform quality control services required of Contractor by authorities having jurisdiction, whether specified or not.

1. Where services are indicated as Contractor's responsibility, engage a qualified testing agency to perform these quality control services. Testing agency shall be acceptable to Engineer and Owner.
a. Contractor shall not employ same entity engaged by Owner, unless agreed to in writing by Owner.
2. Notify testing agencies at least 24 hours in advance of time when Work that requires testing or inspecting will be performed. Notify Owner at least two business days in advance to observe.
3. Where quality control services are indicated as Contractor's responsibility, submit a certified written report, in 2 copies, of each quality control service.
4. Testing and inspecting requested by Contractor and not required by the Contract Documents are Contractor's responsibility.
5. Submit additional copies of each written report directly to authorities having jurisdiction, when they so direct.

1.07 QUALITY ASSURANCE:

A. Owner Responsibilities: Where quality assurance services are indicated Owner will select and pay for a qualified testing agency from their on-call testing agency list to perform these services.

1. Owner will furnish Contractor with names, addresses, and telephone numbers of testing agencies selected and a description of types of testing and inspecting they are to perform.
2. Payment for these services will be made by the Owner. The Contractor shall be responsible for coordination with the testing agency as to the timing of testing operations.
3. Costs for retesting and reinspecting construction that replaces or is necessitated by Work that failed to comply with the Contract Documents will be the responsibility of the Contractor and will be deducted from the Contract Price.

B. Manufacturer's Field Services:

1. Where indicated or specified in respective Equipment specifications, provide services of an experienced, competent, factory-authorized representative of the manufacturer of each item of Equipment.
2. Arrange for Field Services representative to visit the Site of the Work and inspect, check, adjust as necessary, and approve the Equipment installation, including service connections. Field Services representative shall be represent when Equipment is started up and placed into operation, and shall revisit the Site as often as necessary until problems are corrected, and Equipment installation and operation are acceptable to Engineer (and Owner).

3. Submit to Engineer the Field Services representative's completed record forms as required and written report certifying that the Equipment has been properly installed and lubricated; is in accurate alignment; is free from undue stress imposed by connecting piping or anchor bolts; and has been successfully operated under expected full load conditions.

C. Retesting/Reinspecting: The Owner will provide quality control services, including retesting and reinspecting, for construction that replaced Work that failed to comply with the Contract Documents. The Contractor will be responsible for the cost of retesting by the amount being deducted from the Contract Price.

D. Testing Agency Responsibilities: Cooperate with Owner, Engineer, and Contractor in performance of duties. Provide qualified personnel to perform required tests and inspections.
1. Notify Owner, Engineer and Contractor promptly of irregularities or deficiencies observed in the Work during performance of its services.
2. Determine the location from which test samples will be taken and in which in-situ tests are conducted.
3. Conduct and interpret tests and inspections and state in each report whether tested and inspected work complies with or deviates from requirements.
4. Submit a certified written report, in duplicate, of each test, inspection, and similar quality-assurance service through Contractor.
5. Do not release, revoke, alter, or increase the Contract Document requirements or approve or accept any portion of the Work.
6. Do not perform any duties of Contractor.

E. Associated Services: Cooperate with agencies performing required tests, inspections, and similar quality control services, and provide reasonable auxiliary services as requested. Notify agency sufficiently in advance of operations to permit assignment of personnel. Provide the following:
1. Access to the Work.
2. Incidental labor and facilities necessary to facilitate tests and inspections.
3. Adequate quantities of representative samples of materials that require testing and inspecting. Assist agency in obtaining samples.
4. Facilities for storage and field curing of test samples.
5. Delivery of samples to testing agencies.
6. Preliminary design mix proposed for use for material mixes that require control by testing agency.
7. Security and protection for samples and for testing and inspecting equipment at Project Site.

F. Coordination: Coordinate sequence of activities to accommodate required quality assurance and quality control services with a minimum of delay and to avoid necessity of removing and replacing construction to accommodate testing and inspecting.
1. Schedule times for tests, inspections, obtaining samples, and similar activities.

G. Schedule of Tests and Inspections: Prepare a schedule of tests, inspections, and similar quality control services required by the Contract Documents. Submit schedule within 30 days of date established for commencement of the Work.
1. Distribution: Distribute schedule to Owner, Engineer, testing agencies, and each party involved in performance of portions of the Work where tests and inspections are required.

1.08 SPECIAL TESTS AND INSPECTIONS:

A. Special Tests and Inspections: Contractor will engage a qualified testing agency or special inspector to conduct special tests and inspections required by authorities having jurisdiction, and as follows:
   1. Verifying that manufacturer maintains detailed fabrication and quality control procedures and reviewing the completeness and adequacy of those procedures to perform the Work.
   2. Notifying Engineer and Contractor promptly of irregularities and deficiencies observed in the Work during performance of its services.
   3. Submitting a certified written report of each test, inspection, and similar quality control service to Engineer with copy to Contractor and to authorities having jurisdiction.
   4. Submitting a final report of special tests and inspections at Substantial Completion, which includes a list of unresolved deficiencies.
   5. Interpreting tests and inspections and stating in each report whether tested and inspected work complies with or deviates from the Contract Documents.
   6. Retesting and reinspecting corrected work.

PART 2 - PRODUCTS - NOT APPLICABLE.

PART 3 - EXECUTION

3.01 TEST AND INSPECTION LOG:

A. Prepare a record of tests and inspections. Include the following:
   1. Date test or inspection was conducted.
   2. Description of the Work tested or inspected.
   3. Date test or inspection results were transmitted to Engineer.
   4. Identification of testing agency or special inspector conducting test or inspection.

B. Maintain log at Project Site. Post changes and modifications as they occur. Provide access to test and inspection log for Engineer's reference during normal working hours.

3.02 REPAIR AND PROTECTION:

A. General: On completion of testing, inspecting, sample taking, and similar services, repair damaged construction and restore substrates and finishes.
   1. Provide materials and comply with installation requirements specified in other Specification Sections. Restore patched areas and extend restoration into adjoining areas with durable seams that are as invisible as possible.

B. Protect construction exposed by or for quality-control service activities.

C. Repair and protection are Contractor's responsibility, regardless of the assignment of responsibility for quality-control services.

END OF SECTION 01 40 00

SECTION 01 51 00 – TEMPORARY UTILITIES AND FACILITIES

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes requirements of a temporary nature not normally incorporated into final Work. It includes the following:
   1. Utility services.
   2. Construction and support facilities.
   3. Construction aids.
   4. Safety and health.
   5. Fire protection.

1.02 RELATED REQUIREMENTS:

A. Temporary Barriers and Controls: Section 01 57 00.

1.03 REFERENCE STANDARDS:

A. American National Standards Association (ANSI):
   1. A10 Series - Safety Requirements for Construction and Demolition.
B. National Electrical Contractors Association (NECA):
   1. Electrical Design Library - Temporary Electrical Facilities.
C. National Fire Protection Association (NFPA):
   1. 10 - Portable Fire Extinguishers.
   2. 70 - National Electrical Code.
   3. 241 - Safeguarding Construction, Alterations, and Demolition Operations.
D. National Electrical Manufacturers Association (NEMA).
E. Underwriters Laboratories (UL).

1.04 SUBMITTALS:

A. Temporary Utilities: Submit reports of tests, inspections, meter readings, and similar procedures performed on temporary utilities.

1.05 QUALITY ASSURANCE:

A. Regulations: Comply with industry standards and applicable laws and regulations of authorities having jurisdiction, including but not limited to:
   1. Building Code requirements.
   2. Health and safety regulations.
   3. Utility company regulations.
   4. Police, Fire Department, and rescue squad rules.
   5. Environmental protection regulations.
B. Standards:
   1. Comply with NFPA 10 and 241, and ANSI A10 Series standards "Temporary Electrical Facilities."
   2. Comply with NEMA, NECA, and UL standards and regulations for temporary electric service. Install service in compliance with NFPA 70.
C. Inspections: Arrange for authorities having jurisdiction to inspect and test each temporary utility before use. Obtain required certifications and permits.

1.06 PROJECT CONDITIONS:

A. Temporary Utilities: Prepare a schedule indicating dates for implementation and termination of each temporary utility. At the earliest feasible time, when acceptable to Owner, change over from use of temporary service to use of the permanent service.

B. Conditions of Use: Keep temporary services and facilities clean and neat in appearance. Operate in a safe and efficient manner. Take necessary fire prevention measures. Do not overload facilities, or permit them to interfere with progress. Do not allow hazardous, dangerous, unsanitary conditions, or public nuisances to develop or persist on the Site.

PART 2 - PRODUCTS

2.01 MATERIALS AND EQUIPMENT:

A. Provide new materials and equipment. If acceptable to Engineer, undamaged previously used materials and equipment in serviceable condition may be used. Provide materials and equipment suitable for the use intended, of capacity for required usage, and meeting applicable codes and standards. Comply with requirements of DIVISIONS 01 through 46.

B. Water: Provide potable water approved by local health authorities.

C. Water Hoses: Provide 3/4-inch (19-mm), heavy-duty, abrasion-resistant, flexible rubber hoses 100 feet (30 m) long, with pressure rating greater than the maximum pressure of the water distribution system. Provide adjustable shutoff nozzles at hose discharge.

D. Electrical Outlets: Provide properly configured, NEMA-polarized outlets to prevent insertion of 110- to 120V plugs into higher voltage outlets. Provide receptacle outlets equipped with ground-fault circuit interrupters, reset button, and pilot light for connection of power tools and equipment.

E. Electrical Power Cords: Provide grounded extension cords. Use hard-service cords where exposed to abrasion and traffic. Provide waterproof connectors to connect separate lengths of electric cords if single lengths will not reach areas where construction activities are in progress. Do not exceed safe length-voltage ratio.

F. Lamps and Light Fixtures: Provide general service incandescent lamps of wattage required for adequate illumination. Provide guard cages or tempered-glass enclosures where exposed to breakage. Provide exterior fixtures where exposed to moisture.

PART 3 - EXECUTION

3.01 TEMPORARY UTILITIES:

A. General:

1. Engage the appropriate local utility company to install temporary service or connect to existing service. Where utility company provides only part of the service, provide the remainder with matching, compatible materials and equipment. Comply with utility company recommendations.
2. Provide adequate utility capacity at each stage of construction. Prior to availability of temporary utilities at the Site, provide trucked-in services as required for start-up of construction operations.
3. Obtain and pay for temporary easements required to bring temporary utilities to the Project Site, where Owner's permanent easement cannot be used for that purpose.
4. Furnish, install, and maintain temporary utilities required for adequate construction, safety, and security. Modify, relocate, and extend systems as Work progresses. Repair damage caused by installation or use of temporary facilities. Grade the areas of Site affected by temporary installations to required elevations and grades, and clean the area.

Remove on completion of Work or until service or facilities are no longer needed or are replaced by authorized use of completed permanent facilities.

5. The types of temporary construction utilities and facilities required include, but not by way of limitation, water distribution, drainage, dewatering equipment, enclosure of Work, heat, ventilation, electrical power distribution, lighting, hoisting facilities, stairs, ladders, and roads.
6. Inspect and test each service before placing temporary utilities in use. Arrange for required inspections and tests by governing authorities, and obtain required certifications and permits for use.
7. Materials used for temporary service shall not be used in the permanent system unless so specified or acceptable to Engineer.

3.02 TEMPORARY ELECTRICITY AND LIGHTING:

A. Use of Existing System:
   1. Owner's existing system may be used for temporary electricity.
   2. Provide connections to existing facilities, size to provide service required for power and lighting.
   3. Power Source: Make connections to Owner's service, located at point indicated or instructed by Owner.
   4. Modify, supplement, and extend service as necessary to meet needed requirements and prevent overloading of existing system.
   5. Protect system to prevent interference with Owner's normal usage.

3.03 TEMPORARY WATER (AS REQUIRED):

A. Use of Existing System:
   1. Owner's existing system may be used for temporary water.
   2. Make connections to existing facilities to provide water for construction purposes.
      a. Water Source: Make connections to Owner's service located at point indicated or where instructed by Owner.
   3. Modify, supplement, and extend system as necessary to meet temporary water requirements and prevent overloading of existing system.
   4. Regulate system to prevent interference with Owner's usage.

B. Costs of Installation and Operation:
   1. Pay all costs for installation, maintenance, and removal.
   2. Water usage shall be metered and paid for by Contractor.

3.04 TEMPORARY SANITARY FACILITIES:

A. Contractor-Furnished Facilities:
   1. Provide for all construction workers under this Contract and representatives at the Site.
   2. Toilet facilities shall be of the chemical, aerated recirculation, or combustion type, properly vented, and fully enclosed with a glass- fiber-reinforced polyester shell or similar nonabsorbent material.
   3. Supply and maintain toilet tissue, paper towels, paper cups and similar disposable materials as appropriate for each facility. Provide appropriate covered waste containers for used material.

B. Use of Existing Facilities:
   1. Contractor will supply their own facilities.

3.05 TEMPORARY CONSTRUCTION AIDS:

A. General:

1. Provide construction aids and equipment required by personnel and to facilitate the execution of the Work; scaffolds, staging, ladders, stairs, ramps, runways, platforms, railings, hoists, cranes, chutes, and other such facilities and equipment.
2. Materials may be new or used, must be suitable for the intended purpose, and meet the requirements of applicable codes, regulations, and standards.
3. When permanent stair framing is in place, provide temporary treads, platforms, and railings for use by construction personnel.

3.06 TEMPORARY ENCLOSURES:

A. New Construction:

1. Provide temporary enclosure of exterior walls as Work progresses, to provide acceptable working conditions, weather protection for interior materials, allow for effective temporary heating, and to prevent entry of unauthorized persons.
    a. Provide temporary exterior doors with hardware, including being lockable.
    b. Other enclosures shall be removable as necessary for Work and for handling of materials.
2. Restore permanent facilities used for temporary purposes to specified condition.

3.07 TEMPORARY SAFETY AND HEALTH:

A. General: Contractor shall be solely responsible for initiating, maintaining, and supervising all safety and health precautions and programs in connection with the Work. Contractor shall take all necessary precautions for the safety of, and shall provide necessary protections to prevent injury or loss to, all employees on the Work and other persons and organizations who may be affected thereby.

3.08 TEMPORARY FIRE PROTECTION:

A. General:

1. Contractor shall be responsible for development of a fire prevention and protection program for all Work under this Contract.
2. The program shall comply with the applicable provisions for safety and protection specified in the Contract Documents and with applicable parts of the NFPA 10 and 241.
3. Locate fire extinguishers where convenient and effective for their intended purpose, but not less than one extinguisher on each floor at or near such usable stairwell.
4. Store combustible materials in containers in fire-safe locations.
5. Maintain unobstructed access to fire extinguishers, fire hydrants, temporary fire protection facilities, stairways, and other access routes for fighting fires. Prohibit smoking in hazardous fire exposure areas.
6. Provide supervision of welding operations and similar sources of fire ignition.
7. Post warning and instructions at each extinguisher location, and instruct construction personnel on proper use of extinguishers and other available facilities at Project Site. Post local fire department telephone number on or near each telephone instrument at Project Site.

B. Permanent Fire Protection:

1. Complete each fire protection facility at earliest reasonable date, place into operation, and make ready for emergency use.
2. Instruct personnel at Site on availability and proper use.

3.09 INSTALLATION AND REMOVAL:

A. Relocation: Relocate construction aids as required by progress of construction, storage limitations, or Work requirements and to accommodate requirements of Owner and other contractors at the Site.

B. Removal: Remove temporary materials, equipment, and services when construction needs can be met and allowed by use of permanent construction, or at completion of the Project.

C. Repair: Clean and repair damage caused by installation or by use of temporary facilities.
   1. Remove foundations and underground installations for construction aids.
   2. Grade the areas of the Site affected by temporary installations to required elevations and clean the area.

END OF SECTION 01 51 00

SECTION 01 57 00 – TEMPORARY BARRIERS AND CONTROLS

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes General Requirements for:
   1. Safety and Protection of Work and Property.
   2. Barriers.
   3. Security and Protection Facilities Installation.
   4. Environmental Controls.
   5. Access Roads and Parking Areas.
   6. Traffic Control and Use of Roadways.

1.02 RELATED REQUIREMENTS:

A. Section 01 10 00 - "Summary" for work restrictions and limitations.

PART 2 - PRODUCTS – Not Applicable

PART 3 - EXECUTION

3.01 SAFETY AND PROTECTION OF WORK AND PROPERTY:

A. General:
   1. Provide for the safety and protection of the Work and of Materials and Equipment to be incorporated therein, whether in storage on or off the Site. Provide protection at all times against rain, wind, storms, frost, freezing, condensation, or heat so as to maintain all Work and Equipment and Materials free from injury or damage. At the end of each day, all new Work likely to be damaged shall be appropriately protected.
   2. Notify Engineer and Owner immediately at any time operations are stopped due to conditions which make it impossible to continue operations safely or to obtain proper results.
   3. Construct and maintain all necessary temporary drainage and do all pumping necessary to keep excavations, floors, pits, trenches, manholes, and ducts free of water.
   4. Protect floors from damage by proper covering and care when handling heavy equipment, painting, or handling mortar or other such materials. Use proper cribbing and shoring to prevent overloading of floors while moving heavy equipment. Provide metal pans under pipe-threading machines and clean such pans daily, keeping oil off floors. Restore floors to former condition where damaged or stained.
   5. Concrete floors less than 28 days old shall not be loaded without written permission from Engineer.
   6. Restrict access to roofs except as required by the Work. Where access is required, provide protection with plywood, boards, or other suitable materials.

B. Property Other than Owner's:
   1. Provide for the safety and protection of property at the Site or adjacent thereto, including trees, shrubs, lawns, walks, pavements, roadways, structures, utilities, and Underground Facilities not designated for removal, relocation, or replacement in the course of construction. Report immediately to the Owner thereof and promptly repair damage to existing facilities resulting from construction operations.
   2. Names and telephone numbers of representatives of agencies and utilities having jurisdiction over streets and utilities in the Work area can be obtained from Owner. Concerned agencies or utilities shall be contacted a minimum of 24 hours prior to

performing Work, closing streets and other traffic areas, or excavating near underground utilities or pole lines.

3. Operation of valves or other appurtenances on existing utilities, when required, shall be by or under the direct supervision of the owning utility. Coordinate with owning utility prior to any operation.
4. Where fences are to be breached on private property, the owners thereof shall be contacted and arrangements made to ensure proper protection of any livestock or other property thus exposed.
5. The applicable requirements specified for protection of the Work shall also apply to the protection of existing property of others.
6. Before Initial Acceptance of the Work by Owner, restore all property affected by Contractor's operations to the original or better condition. Restoration does not relieve Contractor of obligations that survive Initial Acceptance under the GENERAL CONDITIONS.

3.02 BARRIERS:

A. General:
   1. Furnish, install, and maintain suitable barriers as required to prevent public entry, to protect the public, and to protect the Work, existing facilities, trees, and plants from construction operations. Remove when no longer needed or at completion of Work.
   2. Materials may be new or used, suitable for the intended purpose, but shall not violate requirements of applicable codes and standards or regulatory agencies.
   3. Barriers shall be of a neat and reasonable uniform appearance, structurally adequate for the required purposes.
   4. Maintain barriers in good repair and clean condition for adequate visibility. Relocate barriers as required by progress of Work.
   5. Repair damage caused by installation and restore area to original or better condition. Clean the area.

3.03 SECURITY AND PROTECTION FACILITIES INSTALLATION:

A. The Project Work will be performed within the Wes Brown Water Treatment Plant fenced boundary area; however, Contractor will be responsible for site security if the perimeter fence is taken down to perform the work. Temporary fencing shall be put in place if the fence is removed to maintain site security.
B. Security Enclosure and Lockup: Install temporary enclosure around partially completed areas of construction. Provide lockable entrances or enclosures to prevent unauthorized entrance, vandalism, theft, and similar violations of security. Lock entrances and enclosures at end of each workday. Contractor is responsible for protecting piping, valves, and other equipment from theft or vandalism.
C. Barricades, Warning Signs, and Lights: Comply with requirements of authorities having jurisdiction for erecting structurally adequate barricades, including warning signs and lighting.
D. Temporary Egress: Maintain temporary egress from existing occupied facilities as indicated and as required by authorities having jurisdiction.

3.04 ENVIRONMENTAL CONTROLS:

A. Environmental Protection: Provide protection, operate temporary facilities, and conduct construction as required to comply with environmental regulations and that minimize possible air, waterway, and subsoil contamination or pollution or other undesirable effects.

B. Temporary Erosion and Sedimentation Control: Comply with requirements of EPA Construction General Permit or authorities having jurisdiction, whichever is more stringent.

C. Stormwater Control:
   1. Comply with requirements of authorities having jurisdiction. Provide barriers in and around excavations and subgrade construction to prevent flooding by runoff of stormwater from heavy rains.
   2. Provide methods to control surface water to prevent damage to the Project, the Site, or adjoining properties.
   3. Provide temporary control measures such as berms, dikes, and drains.
   4. Control fill, grading, and ditching to direct surface drainage away from excavations, pits, tunnels, and other construction areas; and to direct drainage to proper runoff.
   5. Provide, operate, and maintain hydraulic equipment of adequate capacity to control surface and groundwater.
   6. Provide temporary drainage where the roofing or similar waterproof deck construction is completed prior to the connection and operation of the permanent drainage piping system.
   7. Coordinate with Thornton Stormwater Department for permitting and closeout/warranty obligations as applicable.

D. Dust Control:
   1. Provide positive methods and apply dust control materials to minimize raising dust from construction operations; and to prevent airborne dust from dispersing into the atmosphere.
   2. Clean interior spaces prior to the start of finish painting and continue cleaning on an as-needed basis until painting is finished.
   3. Schedule operations so that dust and other contaminants resulting from cleaning process will not fall on wet or newly-coated surfaces.

E. Debris Control and Clean-Up:
   1. Keep the premises free at all times from accumulations of debris, waste materials, and rubbish caused by construction operations and employees. Responsibilities shall include:
      a. Adequate trash receptacles about the Site, emptied promptly when filled.
      b. Periodic cleanup to avoid hazards or interference with operations at the Site and to maintain the Site in a reasonably neat condition.
      c. The keeping of construction materials such as forms and scaffolding neatly stacked.
      d. Immediate cleanup to protect the Work by removing splattered concrete, asphalt, oil, paint, corrosive liquids, and cleaning solutions from walls, floors, and metal surfaces before surfaces are marred.
   2. Prohibit overloading of trucks to prevent spillages on access and haul routes. Provide periodic inspection of traffic areas to enforce requirements.
   3. Final cleanup is specified in Section 01 78 00 - Contract Closeout.

F. Pollution Control:
   1. Provide methods, means, and facilities required to prevent contamination of soil, water, or atmosphere by the discharge of hazardous or toxic substances from construction operations.
   2. Provide equipment and personnel, perform emergency measures required to contain any spillages, and remove contaminated soils or liquids. Excavate and dispose of any contaminated earth off-Site in approved locations, and replace with suitable compacted fill and topsoil.

3. Take special measures to prevent harmful substances from entering public waters, sanitary, or storm sewers.

3.05 ACCESS ROADS AND PARKING AREAS:

A. Existing On-Site Roads and Parking Areas:

1. Designated existing on-Site streets and parking facilities may be used for construction traffic.
    a. Maintain existing construction, and restore to original, better, or specified condition at completion of Work.
    b. Do not allow heavy vehicles or construction equipment in parking areas.

3.06 TRAFFIC CONTROL AND USE OF ROADWAYS:

A. Maintenance of Roadways:

1. Repair roads, walkways, and other traffic areas damaged by operations. Keep traffic areas as free as possible of excavated materials and maintain in a manner to eliminate dust, mud, and hazardous conditions.
2. All operations and repairs shall meet the approval of owners or agencies having jurisdiction.
3. All posted speed and safety signage shall be followed.

END OF SECTION 01 57 00

SECTION 01 60 00 – EQUIPMENT AND MATERIALS

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes administrative and procedural requirements governing Contractor's selection of products for use in the Project.

1.02 RELATED REQUIREMENTS:

A. The following Sections contain requirements that relate to this Section:
   1. For the applicability of industry standards to products specified: DIVISIONS 02 through 33.
   2. For submittal of Contractor's construction progress schedule and the Submittal schedule: Sections 01 32 00 and 01 33 00.

1.03 DEFINITIONS:

A. Definitions used in this Article are not intended to change the meaning of other terms used in these Contract Documents, such as "specialties," "systems," "structures," "finishes," "accessories," and similar terms. Such terms are self-explanatory and have well-recognized meanings in the construction industry.
   1. "Products" are items purchased for incorporation in the Work, whether purchased for the Project or taken from previously purchased stock. The term "product" includes the terms "Material," "Equipment," "system," and terms of similar intent.
      a. "Named Products" are items identified by the manufacturer's product name, including make or model number or other designation, shown or listed in the manufacturer's published product literature, that is current as of the date of the Contract Documents.
   2. "Materials" are products substantially shaped, cut, worked, mixed, finished, refined or otherwise fabricated, processed, or installed to form a part of the Work.
   3. "Equipment" is a product with operational or nonoperational parts, whether motorized, or manually operated, that may require service connections, such as wiring or piping.

1.04 SUBMITTALS:

A. Submittal of preliminary procurement schedule is specified in Section 01 32 00 - Construction Progress Schedules and Reports.
B. Submittals for products are specified in Section 01 33 00 and in applicable Sections of DIVISIONS 02 through 33.

1.05 QUALITY ASSURANCE:

A. Source Limitations: To the fullest extent possible, provide products of the same kind from a single source.
B. Compatibility of Options: When the Contractor is given the option of selecting between two or more products for use on the Project, the product selected shall be compatible with products previously selected, even if previously selected products were also options.
C. Nameplates: Along with required labels and operating data, manufacturer or producer's nameplates, imprints, or trademarks may be placed on surfaces exposed to view.
   1. Labels: Locate required product labels and stamps on concealed surfaces or, where required for observation after installation, on accessible surfaces that are not conspicuous.
   2. Equipment Nameplates: Provide a permanent nameplate on each item of service-connected or power-operated Equipment. Locate on an easily accessible surface that is

inconspicuous in occupied spaces. The nameplate shall contain the following information and other essential operating data:

a. Name of product and manufacturer including address (and telephone number).
b. Model and serial number.
c. Capacity.
d. Speed.
e. Ratings.

D. Electronic Equipment Compliance:

1. Contractor warrants that all equipment, devices, items, systems, software, hardware, or firmware provided shall properly, appropriately, and consistently function and accurately process date and time data (including without limitation: calculating, comparing, and sequencing). This warranty supersedes anything in the Specifications or other Contract Documents which might be construed inconsistently. This warranty is applicable whether the equipment, device, item, system, software, hardware, or firmware is specified with or without reference to a manufacturer's name, make, or model number.

1.06 TRANSPORTATION AND SHIPMENT:

A. Shipment Preparation:

1. Contractor shall require manufacturers and Suppliers to prepare products for shipment in a manner to facilitate unloading and handling, and to protect against damage, deterioration, or unnecessary exposure to the elements in transit and storage. Provisions for protection shall include the following:
   a. Crates or other suitable packaging materials.
   b. Covers and other means to prevent corrosion, moisture damage, mechanical injury, and accumulation of dirt in motors, electrical equipment, and machinery.
   c. Suitable rust-preventive compound on exposed machined surfaces and unpainted iron and steel.
   d. Grease packing or oil lubrication in all bearings and similar items.

B. Marking: Each product item shall be tagged or marked as identified in the delivery schedule or on Submittals. Complete packing lists and bills of material shall be included with each shipment. Each piece of every item need not be marked separately, provided that all pieces of each item are packed or bundled together, and the packages or bundles are properly tagged or marked.

1.07 PRODUCT DELIVERY, STORAGE, AND HANDLING:

A. Deliver, store, and handle products according to the manufacturer's recommendations, using means and methods that will prevent damage, deterioration, and loss, including theft.

1. Schedule delivery to minimize long-term storage at the Site and to prevent overcrowding of construction spaces. Allow ample time to avoid delay of the Work.
2. Coordinate delivery with installation time to assure minimum holding time for items that are flammable, hazardous, easily damaged, or sensitive to deterioration, theft, and other losses.
3. Deliver products to the Site in an undamaged condition in the manufacturer's original sealed container or other packaging system, complete with labels and instructions for handling, storing, unpacking, protecting, and installing.
4. Inspect products upon delivery to ensure compliance with the Contract Documents and to ensure that products are undamaged and properly protected. Inspection by Contractor does not constitute acceptance of productions, transfer responsibility for their care and

protection, or relieve Contractor of responsibility for compliance with Contract Documents. Inspect shipment to assure:

a. Product complies with requirements of Contract Documents and reviewed Submittals.
b. Quantities are correct.
c. Containers and packages are intact, and labels are legible.
d. Products are properly protected and undamaged.

5. Store products at the Site in a manner that will facilitate inspection and measurement of quantity or counting of units. Mark deliveries of component parts of Equipment to identify the Equipment, to permit easy accumulation of parts, and to facilitate inspection and measurement of quantity or counting of units.
6. Store heavy Materials away from the Project structure in a manner that will not endanger the supporting construction.
7. Store products subject to damage by the elements above ground, under cover in a weathertight enclosure, and with ventilation adequate to prevent condensation. Maintain temperature and humidity within range required by manufacturer's instructions.
8. Protect motors, electrical Equipment, plumbing fixtures, and machinery of all kinds against corrosion, moisture deteriorations, mechanical injury, and accumulation of dirt or other foreign matter.
9. Protect exposed machined surfaces and unpainted iron and steel as necessary with suitable rust-preventive compounds.
10. Protect bearings and similar items with grease packing or oil lubrication.
11. Handle and store steel plate, sheet metal, and similar items in a manner to prevent deformation.

B. Handling:
1. Provide equipment and personnel necessary to unload and handle products, by methods to prevent damage or soiling to products, or packaging.
2. Handle by methods to prevent bending or overstressing. Where lifting points are designated, lift components only at those points.
3. Provide additional protection to surrounding surfaces as necessary to prevent damage.

C. Maintenance of Storage:
1. Inspect stored products on a scheduled basis.
2. Verify that storage facilities comply with manufacturer's product storage requirements, including environmental conditions continually maintained.
3. Verify that surfaces of products exposed to elements are not adversely affected; that any weathering of finishes is acceptable under requirements of Contract Documents.
4. For mechanical and electrical Equipment in long-term storage, provide manufacturer's service instructions to accompany each item, with notice of enclosed instructions on exterior of package. Service Equipment on a regularly scheduled basis.

D. Protection After Installation: Provide substantial coverings as necessary to protect installed products from damage from subsequent construction operations. Remove coverings when no longer needed or as specified.

1.08 ANSI/NSF 61 REQUIRED MATERIALS:

A. The Colorado Department of Public Health and Environment (CDPHE) requires that the materials in contact with potable water or forward flow in a water treatment plant must be verified as being appropriate for the application by being ANSI/NSF 61 certified. Materials in drinking water systems requiring ANSI/NSF 61 certification include but are not limited to (exempt materials are listed in CDPHE's WQCD Design Criteria for Potable Water):

1. Process Equipment
    a. Chlorine contact chamber system
    b. Potable Denver Water Interconnect system
2. Protective Materials:
    a. Coatings, liners (including tank and pipe coatings/liners)
3. Joining and Sealing Materials:
    a. Solvent cements
    b. Concrete curing compounds
    c. Concrete form release agents
    d. Glues
    e. Caulking
    f. Welding materials
    g. Gaskets
    h. Lubricating oils
    i. Greases
4. Pipes and Related Products:
    a. Plastic pipes and fittings made from non-exempt materials.
    b. Plastic tanks (for water storage) made from non-exempt materials.
5. Potential Lead Containing Appurtenances:
    a. Water meters
    b. Tapping saddles
    c. Corp Stops
    d. Brass, copper or other bronze materials

PART 2 - PRODUCTS

2.01 PRODUCT SELECTION:

A. General Product Requirements: Provide products that comply with the Contract Documents, that are undamaged and, unless otherwise specified or indicated, new at the time of installation.
    1. Provide products complete with accessories, trim, finish, safety guards, and other devices and details needed for a complete installation and the intended use and effect.
    2. Where available, provide standard products of types that have been produced and used successfully in similar situations on other projects.
    3. Continued Availability: Where, because of the nature of its application, Owner is likely to need replacement parts or additional amounts of a product at a later date, either for maintenance and repair or replacement, provide standard products for which the manufacturer has published assurances that the products and its parts are likely to be available to Owner at a later date.
    4. Conform to applicable Specifications, codes, standards, and regulatory agencies.
    5. Comply with size, make, type, and quality specified, or as specifically approved in writing by Engineer.
    6. Manufactured and Fabricated Products:
        a. Design, fabricate, and assemble in accordance with the best engineering and shop practices.
        b. Manufacture like parts of duplicate units to standard sizes and gages, to be interchangeable.
        c. Equipment and Materials shall be suitable for service conditions intended.
        d. Equipment capacities, sizes, and dimensions indicated or specified shall be adhered to unless variations are specifically approved in writing by Engineer.

e. Provide labels and nameplates where required by regulatory agencies or to state identification and essential operating data.

7. Do not use products for any purpose other than that for which designed.
8. To the fullest extent possible, provide products of the same kind from a single source.
9. Any product substitution must comply with Article VII of the GENERAL CONDITIONS.

PART 3 - EXECUTION

3.01 INSTALLATION OF PRODUCTS:

A. Comply with manufacturer's instructions and recommendations for installation of products in the applications indicated. Anchor each product securely in place except as required for proper movement and performance, and accurately located and aligned with other Work.
   1. Obtain and distribute copies of manufacturer's printed instructions and recommendations if not a part of Submittals, containers, or packaging to parties involved in the installation, including a copy to Engineer.
   2. Maintain one complete set of instructions at the Site during installation and until completion.
   3. Handle, install, connect, clean, condition, and adjust products in accordance with such instructions and in conformance with specified requirements. Should job conditions or specified requirements conflict with manufacturer's instructions, consult with Engineer for further instructions.

B. Clean exposed surfaces and protect as necessary to ensure freedom from damage and deterioration at time of Substantial Completion.

END OF SECTION 01 60 00

SECTION 01 75 00 – MANUFACTURER'S FIELD SERVICES

PART 1 - GENERAL

1.01 SUMMARY:

A. This section includes requirements of manufacturers of Equipment and Materials for services to be performed at the Project Site in regards to erection, start-up, and testing of Equipment and Materials.

1.02 SERVICES REQUIRED:

A. Services with Equipment and Materials Furnished Under this Contract:
   1. Furnish the services of qualified field personnel from the Suppliers or manufacturers of Equipment furnished and installed under this Contract, as required to perform all manufacturer's Field Services called for in the Specifications. Field personnel shall be certified by the Supplier or manufacturer of the specific product or system as having the necessary knowledge and experience to perform the required functions.
   2. Where such service is specified, Contractor shall not perform any Work related to the installation or operation of Equipment furnished and installed under this Contract without direct observation and guidance of the Supplier's or manufacturer's field personnel unless Engineer concurs otherwise.
   3. Contractor shall arrange for the Supplier's or manufacturer's field personnel to perform the following:
      a. Observe the erection, installation, start-up, and testing of Equipment.
      b. Instruct and guide Contractor in proper procedures.
      c. Supervise the initial start-up, operational check, and any required adjustments of Equipment.
      d. Instruct Owner's designated personnel in proper operation and maintenance of all Equipment.
      e. Furnish a written report to Engineer covering all Work done at least once each week and when Work on each item of Equipment or system is completed.
   4. Advise Engineer of arrival at the Site of all Supplier's and manufacturer's field personnel.

PART 2 - PRODUCTS: SPECIFIED IN APPLICABLE SECTIONS.

PART 3 - EXECUTION

3.01 OPERATION AND TESTING:

A. Placing Equipment in Operation:
   1. Place all Equipment installed under this Contract (and those furnished by Owner or others under separate contract) into successful operation according to instructions of the Supplier, manufacturer, or field representative, including making all required adjustments, tests, operation checks, and the following:
      a. Cleaning, sounding, blowing out, and flushing of lubricating oil and water systems, and other pipelines.
      b. Lubrication.
      c. Tests of lubrication system safety interlocks and system performance.
      d. Final alignment checks and measurements made under observation of Engineer and Owner. Alignment checks shall include opening connections, if required, to ensure there are no abnormal stresses on Equipment from pipes, ducts, or other attachments. Alignment shall be within tolerances specified by the manufacturer, and measurements shall be recorded and furnished to Engineer.

e. Motor rotation checks before connecting couplings.
f. Inspection of sleeve bearings for adequate contact.
g. Checking of anchor-bolt tensions, grout, and shims. Tighten anchor bolts with calibrated torque wrenches using care not to over stress bolts.

2. After "run-in" and acceptance of alignment, affix major Equipment in place using standard tapered dowels with jack-out nuts at head end to facilitate removal.
3. Record all above operations on forms furnished by Engineer.
4. Furnish all necessary attendants and personnel as part of the Work to accomplish the above operations until such time as individual items, systems, Equipment, or sections of the plant are acceptable for operation by Owner.
5. Provide attendants on a continuous basis as required to complete events without interruption once they have been started.
6. Contractor shall provide electricity for placing Equipment in operation. Owner's operating personnel will assist.

B. Performance Tests:
1. Equipment Furnished Under this Contract:
a. Owner may conduct acceptance tests after installation to determine if the Equipment installed as part of the Work perform in accordance with Contract Documents and as guaranteed. .
b. No tests will be conducted on Equipment for which Supplier’s or manufacturer's Field Service is specified unless Supplier’s or manufacturer's field representative is present and declares in writing that the Equipment is ready for such test.
c. Contractor will be notified by Owner so that Contractor can have a representative or manufacturer's representative present during any tests of Equipment for which Supplier’s or manufacturer's Field Service is not specified.
d. The tests will be made as set forth in the Contract Documents unless the interested parties mutually agree upon some other manner of testing.

END OF SECTION 01 75 00

SECTION 01 78 00 – CONTRACT CLOSEOUT

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes administrative and procedural requirements for Contract closeout including, but not limited to, the following:
   1. Inspection procedures.
   2. Project record document submittal.
   3. Instruction book and operating manual submittal.
   4. Submittal of warranties.
   5. Final cleaning.

B. Closeout requirements for specific construction activities are included in the appropriate Sections of the Specifications.

1.02 RELATED REQUIREMENTS:

A. Requirements for Substantial Completion, Initial Acceptance, Final Payment, Warranty Correction Period, and Final Acceptance: GENERAL CONDITIONS.
B. Submittals: Section 01 33 00.
C. Manufacturer's Field Service: Section 01 75 00.
D. Warranties: Section 01 78 36.

1.03 SUBSTANTIAL COMPLETION:

A. Request, inspection, determination, and documentation of Substantial Completion shall be in accordance with the GENERAL CONDITIONS.

B. Preliminary Procedures: Before requesting inspection for certification of Substantial Completion, complete the following. List exceptions in the request.
   1. In the Application for Payment that coincides with, or first follows, the date Substantial Completion is claimed, show 100% completion for the portion of the Work claimed as Substantially Complete.
      a. Include supporting documentation for completion as indicated in these Contract Documents and a statement showing an accounting of changes to the Contract Price.
      b. If 100% completion cannot be shown, include a list of incomplete items, the value of incomplete Work, and reasons the Work is not complete.
   2. Advise Owner of pending insurance changeover requirements.
   3. Submit available warranties, workmanship Bonds, maintenance agreements, final certifications, and similar documents. Submit final executed warranty documents prior to Initial Acceptance in accordance with the GENERAL REQUIREMENTS.
   4. Obtain and submit releases enabling Owner unrestricted use of the Work and access to services and utilities. Include occupancy permits, operating certificates, and similar releases.
   5. Submit available record drawings, instruction books and operating manuals, final project photographs, damage or settlement surveys, property surveys, and similar final record information. Submit complete and final Record Documents before Initial Acceptance in accordance with the GENERAL CONDITIONS.
   6. Deliver tools, spare parts, extra stock, and similar items.
   7. Make final changeover of permanent locks and transmit keys to Owner. Advise Owner's personnel of changeover in security provisions.

8. Complete start-up testing of systems and instruction of Owner's operation and maintenance personnel. Discontinue and remove temporary facilities from the Site, along with mockups, construction tools, and similar elements.
9. Complete final cleanup requirements, including touchup painting.
10. Touch up and otherwise repair and restore marred, exposed finishes.

C. Inspection Procedures: On receipt of a request for inspection, Owner shall administer the inspection and determination of Substantial Completion in accordance with the GENERAL CONDITIONS. Engineer shall assist Owner in inspections and issuance of incomplete or corrective Work. Engineer's participation, observations, or recommendations do not constitute Substantial Completion, Initial Completion, or Final Acceptance by Owner.

1.04 FINAL PAYMENT:

A. Requirements, procedures, releases, supporting documentation, timing, withholding, and legal effect of Final Payment shall be in accordance with the GENERAL CONDITIONS.

B. Submit the following project-specific closeout documents with or before the final Application for Payment, as applicable:
1. Documentation required by the GENERAL CONDITIONS.
2. Final Record Documents.
3. Final operation and maintenance manuals.
4. Final warranties and bonds.
5. Final training records.
6. Spare-parts and extra-material receipts.
7. Final test and startup reports.
8. Final construction photographs.
9. Final permits, certificates, and regulatory closeout documents.
10. Other closeout submittals required by the Contract Documents.

1.05 INITIAL ACCEPTANCE:

A. Requirements and procedures for Initial Acceptance, including completion of Punch List Work, closeout documentation, Notice of Final Settlement, and commencement of the Warranty Correction Period, shall be in accordance with the GENERAL CONDITIONS.

B. The following project-specific items are conditions of Initial Acceptance, in addition to requirements of the GENERAL CONDITIONS:
1. Complete and final Record Documents.
2. Approved operation and maintenance manuals.
3. Final warranties and bonds.
4. Completed startup, testing, and Owner training.
5. Delivery of required spare parts, tools, and extra materials.
6. Completion of final cleaning.
7. Closure or transfer of permits as directed by Thornton.
8. Completion of other closeout requirements identified in the Contract Documents.

1.06 WARRANTY CORRECTION PERIOD:

A. The Warranty Correction Period, correction of Defective Work, extensions applicable to corrected Work, and Owner's remedies shall be governed by the GENERAL CONDITIONS.

B. Administrative requirements for compiling and submitting warranties are specified in Section 01 78 36.

C. Longer or special warranty periods required for specific products, Equipment, systems, or portions of the Work are specified in the applicable technical Sections.

D. Erosion-control management, maintenance, stabilization, and associated warranty obligations shall comply with the SPECIAL CONDITIONS.

1.07 FINAL ACCEPTANCE

A. Final Acceptance shall have the meaning and shall occur in accordance with the GENERAL CONDITIONS.

B. Before requesting Final Acceptance following expiration of the Warranty Correction Period, Contractor shall:
   1. Complete outstanding warranty and corrective Work.
   2. Submit documentation identifying warranty requests received and the disposition of each request.
   3. Submit updated Record Documents when warranty or corrective Work altered the completed installation.
   4. Submit revised operation and maintenance information when warranty or corrective Work changed Equipment, Materials, settings, components, or maintenance requirements.
   5. Renew or extend warranties applicable to corrected or replaced Work as required by the Contract Documents.
   6. Remove temporary facilities and protection associated with warranty Work.
   7. Repair damage resulting from warranty or corrective Work.

C. Submit a written request for Final Acceptance to Owner. Owner will determine whether the requirements for Final Acceptance have been satisfied. Engineer may assist Owner in reviewing warranty Work, but Engineer shall not independently issue Final Acceptance.

1.08 RECORD DOCUMENT SUBMITTALS:

A. General: Do not use record documents for construction purposes. Protect record documents from deterioration and loss in a secure, fire-resistant location. Provide access to record documents for Engineer's reference during normal working hours.

B. Record Drawings: Contractor shall maintain a clean, undamaged, and detailed set of blue or black line white-prints of Contract Drawings and Shop Drawings. Mark the set to show the actual installation where the installation varies substantially from the Work as originally shown. Mark which drawing is most capable of showing conditions fully and accurately. Where Shop Drawings are used, record a cross-reference at the corresponding location on the Contract Drawings. Give particular attention to concealed elements that would be difficult to measure and record at a later date.
   1. Record information concurrently with construction progress.
   2. Mark record sets with red erasable pencil. Use other colors to distinguish between variations in separate categories of the Work. Mark each document "PROJECT RECORD" in neat, large, printed letters.
   3. Mark new information that is important to Owner but was not shown on Contract Drawings or Shop Drawings.
   4. Note related Change Order numbers where applicable.
   5. Organize record drawing sheets into manageable sets. Bind sets with durable-paper cover sheets; print suitable titles, dates, and other identification on the cover of each set.
   6. Upon completion of the Work, submit record drawings to Engineer for Owner's records.
   7. Include the following:
      a. Depths of various elements of foundation in relation to finish first floor datum.
      b. Horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.

c. Location of internal utilities and appurtenances concealed in the construction, referenced to visible and accessible features of construction.
d. Where Submittals are used for mark-up, record a cross-reference at corresponding location on Drawings.
e. Field changes of dimension and detail.
f. Changes made by Change Order or other Modifications.
g. Details not on original Contract Drawings.

C. Record Specifications: Maintain one complete copy of the Project Manual including Addenda. Include with the Project Manual one copy of other written construction documents, such as Change Orders and Modifications issued in printed form during construction.
1. Mark these documents to show substantial variations in actual Work performed in comparison with the text of the Specifications and modifications.
2. In the Table of Contents or applicable indices mark with an asterisk (*) identifying each revised Section and include the footnote "Revised."
3. Give particular attention to substitutions and selection of options and information on concealed construction that cannot otherwise be readily discerned later by direct observation.
4. Note related record drawing information and product data.
5. Upon completion of the Work, submit record Specifications to Engineer for Owner's records in hardcopy and Microsoft Word format.
6. Include the following:
a. Manufacturer, trade name, catalog number, and Supplier of each product and item of Equipment actually installed, particularly optional and substitute items.
b. Changes made by Addendum, Change Order, or other Modifications.
c. Related Submittals.

D. Record Product Data: Maintain one copy of each product data Submittal. Note related Change Orders and markup of record drawings and specifications.
1. Mark these documents to show significant variations in actual Work performed in comparison with information submitted. Include variations in products delivered to the Site and from the manufacturer's installation instructions and recommendations.
2. Give particular attention to concealed products and portions of the Work that cannot otherwise be readily discerned later by direct observation.
3. Upon completion of markup, submit complete set of record product data to Engineer for Owner's records.

E. Record Samples Submitted: Immediately prior to Substantial Completion, Contractor shall meet with Engineer and Owner's personnel at the Project Site to determine which Samples are to be transmitted to Owner for record purposes. Comply with Owner's instructions regarding packaging, identification, and delivery to Owner.

F. Miscellaneous Record Submittals: Refer to other Specification Sections for requirements of miscellaneous record keeping and Submittals in connection with actual performance of the Work. Immediately prior to the date or dates of Substantial Completion, complete miscellaneous records, and place in good order. Identify miscellaneous records properly and bind or file, ready for continued use and reference. Submit to Engineer for Owner's records.

G. Instruction Books and Operating Manuals: Organize operation and maintenance data into suitable sets of manageable size as specified in Section 01 33 00 and GENERAL CONDITIONS.

H. Electronic Documentation:
1. In addition to paper copies, provide electronic versions of record documents showing "as-constructed" conditions, "as-constructed" construction progress schedule, master field

drawing list showing final revisions, instruction books, and operating manuals. Record drawings shall be submitted on an electronic CAD format compatible with Owner's CAD system. The title block shall indicated "Record Documents" and be dated as the Date of Initial Acceptance.

2. All Drawing changes shall be circled with a "cloud" and any applicable Change Order or Amendment number shall be included in a "delta" adjacent to the cloud and recorded in the title block.

I. Warranties and Bonds: Specified in GENERAL CONDITIONS, Section 01 33 00, and Section 01 78 36.

1.09 SPARE PARTS:

A. Products Required:
   1. Provide to Owner the quantities of products, spare parts, maintenance tools, and maintenance materials specified in individual Sections, in addition to that required for completion of Work.
   2. Products shall be identical to those installed in the Work. Include quantities required from Supplier or manufacturer of original purchase to avoid variations in manufacture.

B. Storage, Maintenance:
   1. Coordinate with Owner. Deliver and unload spare products to Owner at Project Site and obtain receipt prior to final payment.
   2. For portions of the Work accepted and occupied by Owner prior to Substantial Completion, deliver the applicable spare products to Owner at time of acceptance. Obtain receipt.
   3. Maintain spare products in original containers with labels intact and legible, until delivery to Owner.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.01 CLOSEOUT PROCEDURES:

A. Operation and Maintenance Instructions: Arrange for each installer of Equipment that requires regular maintenance to meet with Owner's personnel at Project Site to provide instruction in proper operation and maintenance. Provide instruction by manufacturer's representatives if installers are not experienced in operation and maintenance procedures. Include a detailed review of the following items:
   1. Instruction books and operating manuals.
   2. Record documents.
   3. Spare parts and materials.
   4. Tools.
   5. Lubricants.
   6. Fuels.
   7. Identification systems.
   8. Control sequences.
   9. Hazards, hazardous chemicals data sheets.
   10. Cleaning.
   11. Warranties and bonds.
   12. Maintenance agreements and similar continuing commitments.

B. As part of instruction for operating Equipment, demonstrate the following procedures:

1. Start-up.
2. Shutdown.
3. Emergency operations.
4. Noise and vibration adjustments.
5. Safety procedures.
6. Economy and efficiency adjustments.
7. Effective energy utilization.

C. Manufacturer's Field Services: Specified in Section 01 75 00.

3.02 FINAL CLEANING:

A. General: Contractor shall keep the Site premises free from accumulations of waste materials, rubbish, and other debris resulting from the Work. Regular Site cleaning is included in Section 01 57 00.

B. Cleaning: Employ experienced workers or professional cleaners for final cleaning. Clean each surface or unit to the condition expected in a normal, commercial building cleaning and maintenance program. Comply with manufacturer's instructions.

1. Complete the following cleaning operations before requesting inspection for certification of Substantial Completion.
   a. Remove labels that are not permanent labels.
   b. Clean transparent materials, including mirrors and glass in doors and windows. Remove glazing compounds and other substances that are noticeable, vision-obscuring materials. Replace chipped or broken glass and other damaged transparent materials.
   c. Clean exposed exterior and interior hard-surfaced finishes to a dust-free condition, free of stains, films, and similar foreign substances. Restore reflective surfaces to their original condition. Clean concrete floors to a "broom clean" condition. Vacuum carpeted surfaces.
   d. Wipe surfaces of mechanical and electrical Equipment. Remove excess lubrication and other substances. Clean plumbing fixtures to a sanitary condition. Clean light fixtures and lamps.
   e. Remove debris and surface dirt from limited-access spaces including roofs, plenums, shafts, trenches, equipment vaults, manholes, and similar spaces.
   f. Clean the Site, including landscape development areas, of rubbish, litter, and other foreign substances. Sweep paved areas broom clean; remove stains, spills, and other foreign deposits. Rake grounds that are neither paved nor planted to a smooth, even-textured surface.
   g. Clean and polish plumbing fixtures to a sanitary condition, free of stains including those resulting from water exposure.
   h. Clean light fixtures and lamps so as to function with full efficiency.
2. Remove temporary structures, tools, equipment, supplies, and surplus materials.
3. Remove temporary protection devices and facilities which were installed to protect previously completed Work.
4. Special Cleaning: Cleaning for specific units of Work is specified in applicable Sections of Specifications.

C. Removal of Protection: Remove temporary protection and facilities installed for protection of the Work during construction.

D. Compliance: Comply with regulations of authorities having jurisdiction and safety standards for cleaning. Do not burn waste materials. Do not bury debris or excess materials on the

Owner's property. Do not discharge volatile, harmful, or dangerous materials into drainage systems. Remove waste materials from the Site and dispose of lawfully.

1. Extra materials of value remaining after completion of associated Work become Owner's property. Dispose of these materials as directed by Owner.

E. Repairs:
   1. Repair damaged protective coated surfaces.
   2. Repair roads, walks, fences, and other items damaged or deteriorated because of construction operations.
   3. Restore all ground areas affected by construction operations.

END OF SECTION 01 78 00

SECTION 01 78 36 – WARRANTIES

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes administrative and procedural requirements for warranties required by the Contract Documents, including manufacturers standard warranties on products and special warranties.
   1. Refer to the GENERAL CONDITIONS for terms of the Contractor's period for correction of the Work.

1.02 RELATED SECTIONS:

A. The following Sections contain requirements that relate to this Section:
   1. Procedures for submitting warranties: Section 01 33 00
   2. Contract closeout procedures: Section 01 78 00.
   3. Specific requirements for warranties on products and installations specified to be warranted: DIVISIONS 02 through 33.
   4. Certifications and other commitments and agreements for continuing services to Owner: Specified throughout the Contract Documents.

B. Disclaimers and Limitations: Manufacturer's disclaimers and limitations on product warranties do not relieve Contractor of the warranty on the Work that incorporates the products. Manufacturer's disclaimers and limitations on product warranties do not relieve Suppliers, manufacturers, and Subcontractors required to countersign special warranties with Contractor.

1.03 WARRANTY REQUIREMENTS:

A. Related Damages and Losses: When correcting failed or damaged warranted construction, remove and replace construction that has been damaged as a result of such failure or that must be removed and replaced to provide access for correction of warranted construction.

B. Reinstatement of Warranty: When Work covered by a warranty has failed and been corrected by replacement or rebuilding, reinstate the warranty by written endorsement. The reinstated warranty shall be equal to the original warranty with an equitable adjustment for depreciation.

C. Replacement Cost: Upon determination that Work covered by a warranty has failed, replace or rebuild the Work to an acceptable condition complying with requirements of the Contract Documents. Contractor is responsible for the cost of replacing or rebuilding defective Work regardless of whether Owner has benefited from use of the Work through a portion of its anticipated useful service life.

D. Owner's Recourse: Expressed warranties made to Owner are in addition to implied warranties and shall not limit the duties, obligations, rights, and remedies otherwise available under the Law. Expressed warranty periods shall not be interpreted as limitations on the time in which Owner can enforce such other duties, obligations, rights, or remedies.
   1. Rejection of Warranties: Owner reserves the right to reject warranties and to limit selection to products with warranties not in conflict with requirements of the Contract Documents.

E. Where the Contract Documents require a special warranty, or similar commitment on the Work or part of the Work, Owner reserves the right to refuse to accept the Work, until Contractor presents evidence that entities required to countersign such commitments are willing to do so.

1.04 SUBMITTALS:

A. Submit draft, written warranties to Engineer prior to the date certified for Substantial Completion. Submit complete, properly executed warranty documents prior to Initial Acceptance and in accordance with the GENERAL REQUIREMENTS.

B. If the Certificate of Substantial Completion designates a commencement date for warranties other than the Date of Substantial Completion for the Work, or a designated portion of the Work, submit written warranties upon request of Engineer.

1. When a designated portion of the Work is completed and occupied or used by Owner, by separate agreement with Contractor during the construction period, submit properly executed warranties to Engineer within 15 days of completion of that designated portion of the Work.

C. When the Contract Documents require Contractor, or Contractor and a Subcontractor, Supplier, or manufacturer to execute a special warranty, prepare a written document that contains appropriate terms and identification, ready for execution by required parties. Submit a draft to Owner, through Engineer, for approval prior to final execution.

1. Refer to DIVISIONS 02 through 33 Sections for specific content requirements and particular requirements for submitting special warranties.

D. Form of Submittal: At Substantial Completion, compile two (2) paper copies and One (1) electronic copy of each required warranty properly executed by Supplier, or by Supplier and a Subcontractor. Organize the warranty documents into an orderly sequence based on the table of contents of the Contract Documents.

E. Bind warranties and bonds in heavy-duty, commercial-quality, durable three-ring, vinyl-covered loose-leaf binders, thickness as necessary to accommodate contents, and sized to receive 8-1/2-by-11-inch paper.

1. Provide heavy paper dividers with celluloid covered tabs for each separate warranty. Mark the tab to identify the product or installation. Provide a typed description of the product or installation, including the name of the product, and the name, address, and telephone number of the installer.
2. Identify each binder on the front and spine with the typed or printed title "WARRANTIES," and as required by Section 01 33 00.
3. When warranted construction requires operation and maintenance manuals, provide additional copies of each required warranty, as necessary, for inclusion in each required manual.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION (NOT APPLICABLE)

END OF SECTION 01 78 36

DIVISION 2 – EXISTING CONDITIONS

SECTION 02 41 13 – SELECTIVE DEMOLITION

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes the removal of existing construction to limits as indicated and specified herein. Demolition includes, but may not be limited to, the complete or partial removal and disposal of materials of the following:
   1. Piping, valves, manholes, yard hydrants, vaults.
   2. Equipment.
   3. Other items as indicated.

B. Related Work Specified Elsewhere:
   1. Site Preparation and Earthwork: SECTION 31 20 00.
   2. Utilities: DIVISION 33.
   3. Electrical Requirements: DIVISION 26.

1.02 SUBMITTALS:

A. Schedule of Demolition:
   1. Submit as specified in DIVISION 1.
   2. Submit proposed methods and operations of demolition for review prior to the start of Work. Include in the schedule the coordination for shutoff, capping, and continuation of utility services as required.
   3. Provide a detailed sequence of demolition and removal Work to ensure the uninterrupted progress of Owner's operations.

1.03 JOB CONDITIONS:

A. Owner will be continuously occupying areas of the Site adjacent to areas of selective demolition. Conduct selective demolition Work in a manner that will minimize need for disruption of Owner's normal operations. Provide Owner a minimum of 72 hours' advance notice of demolition activities which will severely impact Owner's normal operations.

B. Condition of Structures to be Demolished:
   1. Owner assumes no responsibility for actual condition of structures to be demolished.
   2. Owner's removal and salvage operations will be complete prior to start of demolition Work.

C. Protections:
   1. Ensure the safe passage of persons around the area of demolition. Conduct operations to prevent injury to adjacent buildings, structures, other facilities, and persons.
   2. Provide interior and exterior shoring, bracing, or support to prevent movement, settlement, or collapse of structures to be demolished and adjacent facilities to remain.
   3. Protect from damage existing finished facilities that are to remain in place and become exposed during demolition operations.
   4. Protect floors with suitable coverings when necessary.
   5. Construct temporary, insulated, solid, dustproof partitions where required to separate areas where noisy or extensive dirt or dust operations are performed. Equip partitions with dustproof doors and security locks if required.
   6. Provide temporary weather protection during interval between demolition and removal of existing construction on exterior surfaces, and installation of new construction to ensure that no water leakage or damage occurs to structure or interior areas of existing building.
   7. Remove protections at completion of Work.

D. Explosives: The use of explosives will not be permitted.
E. Traffic:
    1. Conduct demolition operations and the removal of debris to ensure minimum interference with roads, streets, walks, and other adjacent occupied or used facilities.
    2. Do not close, block, or otherwise obstruct streets, walks, or other occupied or used facilities without permission from the governing authority or Owner. Provide alternate routes around closed or obstructed traffic ways if required by governing authorities.
F. Promptly repair damages caused to adjacent facilities by demolition operations at no cost to Owner.
G. Utility Services:
    1. Maintain existing utilities; keep in service and protect against damage during demolition operations.
    2. Do not interrupt existing utilities serving occupied or used facilities, except when authorized in writing by Engineer, Owner, or authorities having jurisdiction. Provide temporary services during interruptions to existing utilities.
    3. Owner will shut off utilities serving each area. Disconnecting and sealing indicated utilities before starting demolition operations shall be done by Owner.

PART 2 - PRODUCTS

2.01 SALVAGE OF MATERIALS:

A. Remove, store, redesign as required, and reinstall as equipment as indicated throughout Construction Drawings.
B. Contractor shall coordinate with Owner and Engineer regarding specific equipment and materials to be returned to the Owner after removal or placed in an Owner-designated location.

2.02 HANDLING AND STORAGE:

A. Carefully dismantle Equipment and Materials to be reused or returned to Owner in a manner to avoid damage.
B. Store Equipment and Materials to be reused in a manner to avoid corrosion, staining, breakage, or damage from any cause.

PART 3 - EXECUTION

3.01 INSPECTION:

A. Prior to commencement of demolition Work, inspect areas in which demolition will be performed. Photograph existing conditions of structures, surfaces, equipment, or surrounding properties according to SECTION 01 32 33 which could be misconstrued as damage resulting from demolition operations. File with Owner prior to starting Work.
B. All equipment required for removals shall be provided by the Contractor.

3.02 PREPARATION:

A. Provide interior and exterior shoring, bracing, or support to prevent movement, settlement, or collapse of structures to be demolished and adjacent facilities to remain:
    1. Cease operations and notify Owner immediately if safety of structure appears to be endangered. Take precautions to support structure until determination is made for continuing operations.
    2. Cover and protect furniture, fixtures, and other items to remain from soiling or damage when demolition Work is performed in rooms or areas from which such items have not been removed.

B. Locate, identify, stub off, and disconnect utility services that are indicated to remain:
   1. Provide bypass connections as necessary to maintain continuity of service to occupied areas of building. Provide minimum of 72 hours' advance notice to Owner if shutdown of service is necessary during changeover.

3.03 DEMOLITION:

A. Perform demolition in a systematic manner. Use such methods as required to complete demolition indicated on Drawings in accordance with demolition schedule and governing regulations:
   1. Demolish concrete and masonry in small sections. Cut concrete and masonry at junctures with construction to remain using power-driven masonry saw or hand tools. Power-driven impact tools shall be used only for demolition outside of structures.
   2. Locate demolition equipment throughout structure and promptly remove debris to avoid imposing excessive loads on supporting walls, floors, or framing.
   3. Provide services for effective air and water pollution controls as required by local authorities having jurisdiction.
   4. Demolish foundation walls to a depth of not less than 12 inches below existing ground surface. Demolish and remove below-grade wood or metal construction. Break up below-grade concrete slabs in a manner that makes the slab porous.
   5. For interior slabs on grade, use removal methods that will not crack or structurally disturb adjacent slabs or partitions. Use power saw where possible.
   6. Completely fill below-grade areas and voids resulting from demolition. Provide fill consisting of approved earth, gravel, or sand; free of trash and debris, frost and frozen materials, stones over 6-inch diameter, roots, or other organic matter. Use satisfactory soil materials and place as specified in SECTION 31 20 00.
   7. Demolition of Roads or Paved Areas: Break up and remove construction including surface, base, and subbase unless otherwise indicated to remain.
   8. Fences: Remove fence construction including fabric, posts, other components, and any below-grade construction such as concrete.

B. If unanticipated mechanical, electrical, or structural elements which conflict with intended function or design are encountered, investigate and measure both nature and extent of the conflict. Engineer and Owner will confer to determine the appropriate actions. The demolition schedule shall be rearranged as necessary to continue overall job progress.

C. Doors, Windows, Borrowed Lites: Remove items to extent indicated, including frames, glass, hardware, and wall anchors. Patch jambs and anchor holes where walls are to remain.

D. Equipment, Ducts, Lighting Fixtures, Piping, Conduit, Brackets, Hangers, and Supports: Remove items to extent indicated, including ceiling, wall, and floor anchors. Patch anchor holes where ceiling, walls, and floors are to remain.

E. Drywall or Plaster Partitions: Remove gypsum board or plaster, steel framing, runners, tracks, anchors, and fasteners. Patch anchor holes where ceiling, walls, and floors are to remain.

F. Suspended Ceilings: Remove panels or tile to extent indicated, suspension system framing (and subframing if part of total suspension system), and hangers. Cut hangers just below attachment to structure if they cannot be completely removed.

G. Pollution Controls:
   1. Use water sprinkling, temporary enclosures, and other suitable methods to limit the amount of dust and dirt rising and scattering in the air to the lowest practical level. Comply with governing regulations pertaining to environmental protection.
   2. Do not use water when it may create hazardous or objectionable conditions such as ice, flooding, and pollution.

3. Clean adjacent structures and area of dust, dirt, and debris caused by demolition operations.

3.04 SALVAGE MATERIALS:

A. Salvage Items:
   1. Where indicated on Drawings and Specifications, carefully remove items. Clean, store, and turn over to Owner and obtain receipt. When applicable, reinstall equipment per designs and specifications.
   2. Historic artifacts, including cornerstones and their contents, commemorative plaques and tablets, antiques, and other articles of historic significance remain the property of Owner. Notify Owner if such items are encountered, and obtain acceptance regarding method of removal and salvage for Owner.

3.05 DISPOSAL OF DEMOLITION MATERIALS:

A. Remove debris, rubbish, and other materials resulting from demolition operations.
B. If hazardous materials are encountered during demolition operations, comply with applicable regulations, laws, and ordinances concerning removal, handling, and protection against exposure or environmental pollution.
C. Burning of removed materials from demolished structures will not be permitted on the Site.
D. Transport materials removed from demolished structures and dispose of off the Site.

3.06 CONNECTIONS TO EXISTING CONSTRUCTION:

A. Cut and remove portions of existing construction as required to allow for proper installation of new construction.
B. Shore and brace existing structure until permanent supports are completed, and to maintain structure in a safe condition.
C. Repair all damage as a result of installation of shoring and bracing.
D. Cap, seal, or abandon pipe and cable as indicated.

3.07 CLEANUP AND REPAIR:

A. Upon completion of demolition Work, remove tools, equipment, and demolished materials from site. Remove protections and leave interior areas broom clean.
B. Repair demolition performed in excess of that required. Return structures and surfaces that will remain to condition existing prior to commencement of demolition Work. Repair adjacent construction or surfaces soiled or damaged by demolition Work.

END OF SECTION 02 41 13

DIVISION 03 – CONCRETE

SECTION 03 30 50 – CONCRETE, FORMWORK, AND REINFORCEMENT

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes concrete, formwork, concrete reinforcement, and miscellaneous concrete accessories.

1.02 REFERENCE STANDARDS:

A. Comply with the provisions of the following codes, specifications, and standards, except as otherwise indicated or specified.

B. Publication Dates: Comply with standards in effect as of date of the Contract Documents, unless otherwise indicated or specified.

C. Applicable Standards:

1. American Concrete Institute (ACI):
   a. ACI SPEC 117 – Specification for Tolerances for Concrete Construction and Materials.
   b. ACI PRC 211.1 – Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete.
   c. ACI SPEC 301 – Standard Specifications for Structural Concrete.
   d. ACI PRC 304 – Guide for Measuring, Mixing, Transporting, and Placing Concrete.
   e. ACI SPEC 305.1 – Standard Specification for Hot Weather Concreting.
   f. ACI PRC 305 – Guide to Hot Weather Concreting.
   g. ACI SPEC 306.1 – Standard Specification for Cold Weather Concreting.
   h. ACI PRC 306 – Guide to Cold Weather Concreting.
   i. ACI SPEC 308.1 – Standard Specification for Curing Concrete.
   j. ACI PRC 309 – Guide for Consolidation of Concrete.
   k. ACI PRC 315 – Guide to Presenting Reinforcing Steel Design Details.
   l. ACI CODE 318 – Building Code Requirements for Structural Concrete.
   m. ACI PRC 347 – Guide to Formwork for Concrete.
   n. ACI MNL 66 – Detailing Manual.
2. ASTM International (ASTM):
   a. ASTM A36/A36M – Standard Specification for Carbon Structural Steel.
   b. ASTM A123/A132M – Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   c. ASTM A143/A143M – Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement.
   d. ASTM A384/A384M – Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies.
   e. ASTM A615/A615M – Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   f. ASTM A706/A706M – Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement.
   g. ASTM A1064/A1064M – Standard Specification for Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
   h. ASTM C31/C31M – Standard Practice for Making and Curing Concrete Test Specimens in the Field.

i. ASTM C33/C33M – Standard Specification for Concrete Aggregates.
j. ASTM C39/C39M – Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
k. ASTM C88/C88M – Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
l. ASTM C94/C94M – Standard Specification for Ready-Mixed Concrete.
m. ASTM C143/C143M – Standard Test Method for Slump of Hydraulic Cement Concrete.
n. ASTM C150/C150M – Standard Specification for Portland Cement.
o. ASTM C172/C172M – Standard Practice for Sampling Freshly Mixed Concrete.
p. ASTM C192/C192M – Standard Practice of Making and Curing Concrete Test Specimens in the Laboratory.
q. ASTM C231/C231M – Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
r. ASTM C233/C233M – Standard Test Methods for Air-Entraining Admixtures for Concrete.
s. ASTM C260/C260M – Standard Specification for Air-Entraining Admixtures for Concrete.
t. ASTM C309 – Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
u. ASTM C494/C494M – Standard Specification for Chemical Admixtures for Concrete.
v. ASTM C595/C595M – Standard Specification for Blended Hydraulic Cements.
w. ASTM C618 – Standard Specification for Coal Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
x. ASTM C1064/C1064M – Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.
y. ASTM C1107/C1107M – Standard Specification for Packaged Dry, Hydraulic Cement Grout (Non-shrink).
z. ASTM C1193 – Standard Guide for Use of Joint Sealants.
aa. ASTM C1260 – Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method).
bb. ASTM C1315 – Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete.
cc. ASTM F436/F436M – Standard Specification for Hardened Steel Washers Inch and Metric Dimensions.
dd. ASTM F1554 – Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength.

3. American Welding Society (AWS):
   a. D1.1 – Structural Welding Code – Steel.
4. Concrete Reinforcing Steel Institute (CRSI):
   a. RB4.1 – Standard for Supports for Reinforcement Used in Concrete.
   b. Manual of Standard Practice.
5. Concrete Plant Manufacturers Bureau (CPMB):
   a. 100 – Concrete Plant Standards.
   b. 102 – Recommended Guide Specifications for Batching Equipment and Control Systems in Concrete Batch Plants.
6. Truck Mixer Manufacturers Bureau (TMMB):
   a. Truck Mixer, Agitator and Front Discharge Concrete Carrier Standards.

7. Volumetric Mixer Manufacturer's Bureau (VMMB):
    a. 100 – Volumetric Mixer Standards.

1.03 SUBMITTALS:

A. Submit as specified in DIVISION 01.

B. Include, but not limited to, the following:

1. Reinforcing steel Submittals as specified below are required for all Work.
    a. Complete reinforcing-bar schedule, reinforcing-bar details, and erection drawings to conform to ACI PRC 315 and ACI MNL 66.
    b. Each type of reinforcing bar shall be marked with identification corresponding to identification tag on bar.
    c. Erection drawings shall be clear, easily legible, and to a minimum scale of:
        (1) 1/4 inch = 1 foot.
        (2) 1/8 inch = 1 foot if bars in each face are shown in separate views.
    d. Size and location of all openings.
    e. Concrete protective cover.
    f. Grade of steel.
    g. Lap splice lengths.
    h. Total weight of reinforcing steel for each structure.
2. Concrete Mix:
    a. Submit one complete concrete mix submittal to include all components of the concrete. The complete concrete mix submittal shall be sealed by a registered professional engineer to ascertain the materials meet these Specifications. The following shall be included in the complete concrete mix design submittal:
        (1) Concrete characteristics (strength, slump, air content, etc.).
        (2) Concrete mix proportions including but not limited to water-cement(itious) ratio, cement content, pozzolan content, aggregate proportions.
        (3) Fine and coarse aggregate data including but not limited to sieve analysis, fineness modulus, deleterious substances, reactivity, and soundness.
        (4) Admixture data sheets and quantities to be used in mix.
        (5) Alkali-reactivity testing.
        (6) Cement mill certification.
        (7) Supplemental cementitious material certifications.
    b. Provide and submit statement that the concrete mix design and materials represented by the complete concrete mix design submittal to be incorporated into the Work has at least 3 years of acceptable performance record.
    c. Provide and submit statement of approved service record of at least 3 years with a history indicating that the fine and/or coarse aggregate is not chemically reactive.
3. Product datasheets.
    a. Non-shrink grout.
    b. Curing agent.
    c. Bonding agents.
    d. Admixtures.
    e. Expansion Joints.
    f. Joint sealants.
4. Embedded plate fabrication drawings.

1.04 QUALITY ASSURANCE:

A. All concrete work shall be in conformance with ACI SPEC 301.

B. Field Testing: Shall be performed by an ACI Concrete Field Testing Technician Grade 1.
   1. Submit qualification records for field testing technicians prior to placing concrete.

PART 2 - PRODUCTS

2.01 CONCRETE MATERIALS:

A. Cement:
   1. Conform to ASTM C150/C150M. Portland cement Type /II.
   2. Conform to ASTM C595/C595M, Type IL(MS).

B. Fine Aggregates: Clean natural sand. Manufactured sand may be used upon written approval of Engineer. Conform to ASTM C33/C33M.
   1. Aggregates shall be tested for alkali reactivity in accordance with ASTM C1260 and soundness in accordance with ASTM C88/C88M.

C. Coarse Aggregates: Clean crushed stone or processed gravel, not containing organic materials. Conform to ASTM C33/C33M.
   1. Aggregates shall be tested for alkali reactivity in accordance with ASTM C1260 and for soundness in accordance with ASTM C88/C88M.
   2. For concrete encasement of electrical ducts, maximum nominal aggregate size shall be 3/8-inch (No. 8).
   3. For foundations, equipment pads, and structural concrete, maximum nominal aggregate size shall be 3/4-inch (No. 67).

D. Mixing Water: Only potable water will be acceptable.

E. Air Entrainment Admixture: Conform to ASTM C260/C260M.

F. Water-Reducing Admixture: Conform to ASTM C494/C494M, Type A.

G. Admixtures shall not contain chloride ions.

H. Supplemental Cementitious Materials:
   1. Fly Ash: Conform to ASTM C618, Class F.

I. Other admixtures: Other admixtures may be added as long as they will not detrimentally affect the finish product or use of the finished product as intended.

2.02 CONCRETE MIX PROPORTIONS:

A. Comply with ACI CODE 318 and ACI PRC 211.1.

B. Concrete Qualities Required:
   1. Minimum Compressive Strength:
      a. For concrete encasement of electrical ducts, f'_c = 4000 psi minimum at 28 days.
      b. For foundations, equipment pads, and structural concrete, f'_c = 4500 [5000] psi minimum at 28 days.
   2. Water/Cement Ratio:
      a. For concrete encasement of electrical ducts, w/c(m) = 0.55 maximum.
      b. For foundation, equipment pads, and structural concrete, w/c(m) = 0.45 maximum.
   3. Slump (prior to the addition of any water reducing admixtures): 4 inches, $\pm$1 inch, as tested in accordance with ASTM C143/C143M.
   4. Air Content:
      a. 6% $\pm$1.5% unless otherwise indicated or specified and tested in accordance with ASTM C231/C231M
   5. Water-Soluble Chloride Ion Content (in percent by weight of cement): 0.30 maximum.
   6. Supplemental Cementitious Materials
      a. Fly Ash: Up to 25% by weight.
      b. Slag Cement: Up to 40% by weight.

C. Ready-Mixed Concrete:
   1. Concrete shall meet requirements of ASTM C94/C94M and of materials and proportions specified.
   2. Ready-mixed concrete plant shall be subject to approval of Engineer.
      a. Ready-mixed concrete plant shall conform to the Concrete Plant Manufacturer's Bureau (CPBM) Standard 100 and Standard 120.
      b. Ready-mixed truck mixers shall conform to TMMB standards.
      c. Volumetric ready-mix trucks shall conform to VMMB standards.

2.03 FORMWORK:

A. Comply with ACI PRC 347.
B. Formwork Materials:
   1. Use one of the following:
      a. Exterior Grade Plywood: 5/8-inch-thick (use only plywood or steel for all concrete that will be exposed to view after construction).
      b. Steel.
      c. Approved wood fiberboard.
      d. Dressed lumber free of loose knots.
   2. Form Ties:
      a. Break-back, coil, or screw-type, except where otherwise specified.
   3. Chamfer Strips:
      a. 3/4-inch chamfer except where otherwise indicated.
      b. Place in all forms to provide chamfer where concrete will have exposed projecting corners.

2.04 CONCRETE REINFORCEMENT:

A. Reinforcement Bars: Conform to ASTM A615/A615M, Grade 60 or ASTM A706/A706M, Grade 60.
B. Welded Wire Fabric: Conform to ASTM A1064/A1064M. Wire size W1.4 or smaller shall be galvanized. Provide mats only. Rolled fabric is not acceptable.
C. Bolsters, Chairs, and Accessories:
   1. Conform to ACI MNL 66, CRSI Manual of Standard Practice, and CRSI-RB4.1.
   2. Metal accessories shall be galvanized or plastic-coated where legs will be exposed in finished concrete surfaces.
   3. Do not use rocks, broken bricks, wood blocks, or concrete fragments for support of steel reinforcement.
D. Concrete cover on reinforcing steel shall not be less than allowed by ACI CODE 318 for concrete based on the 'concrete exposed to earth or weather' criteria unless otherwise indicated.

2.05 PRE-PACKAGED NON-SHRINK CEMENTITIOUS GROUT:

A. Non-shrink cement-based grout shall consist of portioned prepackaged manufactured grout in accordance with ASTM C1107/C1107M.
   1. Minimum of 5000 psi 28-day compressive strength as determined in accordance with ASTM C1107/C1107M.
   2. Acceptable Products:
      a. BASF Corporation Construction Solutions, Shakopee, MN – MasterFlow 713.
      b. Dayton Superior Corporation, Miamisburg, Ohio – 1107 Advantage Grout.
      c. Euclid Chemical Co., Cleveland, Ohio – NC Grout.

d. Five Star Products Inc., Shelton, Connecticut – Five Star Grout.
e. Five Star Products Inc., Shelton, Connecticut – Fluid Grout 100.
f. Lacticrete International Inc., Bethany, Connecticut – L&M Construction Chemicals Crystex.
g. Unisorb, Jackson, Michigan – V-1.
h. Engineer-approved equal.

B. Prepare surfaces to receive grout in accordance with manufacturer's recommendations and the following:
1. For cementitious grouting, hardened concrete surfaces upon which grout is to be placed shall be mechanically chipped to remove unsound concrete, laitance, surface mortar, rust, oil, grease, and any other contaminants that may inhibit bonding.
2. Clean surface of all dust and loose material after chipping.
3. Immediately prior to grout placement, saturate concrete substrate with water for minimum 24 hours. Remove excess water so that surface is damp but with no free-standing water present (saturated surface dry) immediately prior to grout placement.

C. Grout shall be dry-packed, flowed, or pumped into place in accordance with grout manufacturer's instructions. Dry-packed grout shall only be used where there is adequate accessibility and with Engineer approval.

D. Cure grout in accordance with manufacturer's recommendations.

2.06 BONDING AGENT:

A. Epoxy Bonding Agent
1. Provide moisture-insensitive, epoxy-resin bonding agent conforming to ASTM C881/C881M, Type V.
2. Acceptable Products:
a. Dayton Superior – Sure Bond J58.
b. Euclid Chemical Company – Dural 452MV.
c. Master Builders Solutions – Master Builders MasterEmaco ADH 1090RS.
d. Sika Chemical Company – Sikadur 32 HiMod.
e. SpecChem LLC – SpecPoxy 2000.

2.07 CURING AGENT:

A. Apply to all concrete surfaces unless otherwise indicated or specified.

B. Curing shall be maintained for a minimum of seven (7) days. If the curing membrane is damaged during this time, re-apply curing compound.

C. Curing agent shall conform as follows:
1. For use where concrete surface is not exposed to direct sunlight after placement:
a. ASTM C309 Type 1.
b. ASTM C1315 Type I Class A.
2. For use where concrete surface is exposed to direct sunlight for a period of seven (7) days minimum after placement:
a. ASTM C309 Type 1 or 1-D.
(1) Curing agents with fugitive dye shall be readily distinguishable upon the concrete surface for at least four (4) hours after application but shall be inconspicuous within seven (7) days after application.
b. ASTM C1315 Type I Class A.
3. For use as specified in PART 3, Article 3.08 – HOT WEATHER CONCRETING:
a. ASTM C309 Type 2.

b. ASTM C1315 Type II Class B.

4. For use where concrete surface is to receive a future floor coating system:
   a. ASTM C1315 Type I, Class A.

D. Curing compound shall be guaranteed not to interfere with application of any coatings to be applied to the concrete after 28-day curing period.

E. Curing compound shall be VOC compliant with a maximum VOC content of 2.9 lbs/gal (350 g/L), or less where Project location regulations are more stringent.

2.08 CAST-IN-PLACE ANCHORS

A. Furnish and install sizes indicated.

B. Cast-in-place anchor rods shall conform to ASTM F1554, Grade 36 unless otherwise indicated. Washers shall conform to ASTM F436/F436M.

C. Galvanize anchor rods, nuts, and washers unless otherwise indicated in accordance with ASTM A123/A123M and F2329/F2329M.

2.09 CONCRETE ANCHORS:

A. Furnish and install manually expanded and/or adhesive anchor types as indicated.

B. Furnish sizes and types indicated. Install to conform to manufacturer's printed instructions.

C. Concrete anchors not indicated to be stainless steel shall be galvanized in accordance with manufacturer’s standard unless otherwise indicated.

D. Anchors indicated to be stainless steel shall be manufactured from 300 series stainless steel per manufacturer’s standard unless specifically indicated to conform to Type 304, 316.

E. Installed adhesive anchors shall not be disturbed or loaded until the anchor has been in place longer than the manufacturer's cure time for the adhesive.

2.10 EMBEDDED STEEL PLATES:

A. Furnish and install embedded plates as indicated.

1. Embedded steel plates shall conform to ASTM A36/A36M.
2. Headed stud connectors shall be per AWS D1.1 Clause 9, with material conforming to AWS D1.1 Clause 9 Table 9.1, Type B.
3. Headed stud connectors shall be welded to embedded plates in accordance with AWS D1.1 Clause 9 requirements.

B. Embedded steel plates and headed stud assemblies shall be hot-dip galvanized in accordance with ASTM A123/A123M. Safeguard against embrittlement in accordance with ASTM A143/A143M and against warping and distortion in accordance with ASTM A384/A384M.

PART 3 - EXECUTION

3.01 GENERAL

A. All Work, this Section, shall be in conformance with ACI SPEC 301.

3.02 FORMWORK:

A. Conform to ACI SPEC 301, ACI CODE 318, and ACI PRC 347, except Shop Drawings for formwork, shoring, and reshoring shall not be submitted for approval.

B. Adequately brace and stiffen formwork to prevent deflection and settlement.

C. Construct and maintain forms to the tolerances given in ACI SPEC 117.

D. Surface of forms shall provide a smooth, dense, plane surface to finished concrete where exposed to view after construction.

E. Treat formwork with commercially available form-releasing agents that will not bond with, stain, or adversely affect concrete surfaces. Agents shall not impair subsequent treatment of concrete surfaces depending upon bond or adhesion, nor shall it impede the wetting of surfaces to be cured with water or curing compounds. Form releasing agents shall be VOC compliant with a maximum VOC content of 3.8 lbs/gal (450 g/L), or less where area restrictions are more stringent.
F. Wet formwork with clean, clear water prior to placing concrete.
G. Formwork shall be left in place until it is safe to remove.
H. Formwork shall not be removed unless the minimum time or minimum compressive strength requirements below are met.
   1. Formwork Not Supporting Weight of Concrete:
      a. Formwork for walls, columns, sides of beams, gravity structures, slabs-on-ground and other vertical type formwork not supporting the weight of concrete shall remain in place 24-hours minimum after concrete placement is completed.
   2. Formwork Supporting Weight of Concrete:
      a. Formwork supporting weight of concrete and shoring shall not be removed until structural members have acquired sufficient strength to safely support their own weight and any construction or other superimposed loads to which the supported concrete may be subjected. As a minimum, no forms or shoring shall be loosened or removed until control concrete test cylinders indicate the concrete has attained the following compressive strengths for the respective structural members:

Structural Member	Percent of Design Compressive Strength
Unshored slab and beam forms or forms which can be removed without disturbing shores	70
Slab or beam shoring	85

3.03 CONCRETE REINFORCEMENT:

A. Place all reinforcing steel before concrete is cast in accordance with approved erection drawings, ACI SPEC 117, ACI CODE 318, and the CRSI Manual of Standard Practice.
B. Remove oil, mill scale, pitting, mud, loose rust, ice, and other materials that would reduce bond from bars before placing.
C. Tie securely with 16-gage or larger annealed iron wire.
D. Place to maintain concrete cover to conform to ACI SPEC 117 and ACI CODE 318, unless otherwise indicated.
E. Splice reinforcing steel where indicated. Unless otherwise indicated, the minimum length of lap for tension lap splices shall be for Class B splices as defined by ACI CODE 318.
F. Lap welded wire fabric not less than the length of one mesh.

3.04 FIELD TESTING:

A. Field Testing of Concrete and Making of Concrete Test Cylinders:
   1. Furnish test equipment, test cylinder molds, and certified personnel to perform all required field tests, make the required concrete test cylinders, and deliver test cylinders to the testing laboratory. The prescribed tests shall be made in the presence of or with the concurrence of Owner.
   2. Test concrete and make test cylinders conforming to ASTM C31/C31M, C143/C143M, C172/C172M, and C231/C231M. Samples shall be taken at random and at the point of concrete placement.

3. Perform slump and air content tests throughout any placement as required to maintain constant quality of fresh concrete, and when directed by Engineer.
4. Record concrete and ambient temperature at times of concrete sampling and testing in accordance with ASTM C1064/C1064M.
5. Field testing personnel shall remain on Site throughout placement of concrete.
6. Make not less than the specified number of test cylinders for each 50 cubic yards of concrete or fraction thereof for each day concrete is placed. Deliver to testing laboratory within 24 hours after taking cylinders. Exercise care not to damage cylinders in transit.
   a. For 6-inch diameter x 12-inch test cylinder, make minimum six (6) cylinders for each sampling of fresh concrete.
   b. For 4-inch diameter x 8-inch test cylinder, make minimum nine (9) cylinders for each sampling of fresh concrete.

B. Laboratory Testing:
1. An independent testing laboratory [will be selected and paid for by Owner] [shall be selected and paid for by Contractor] [will be selected and paid for by Contractor] [shall be selected and paid for by Subcontractor] to perform the required laboratory tests.
2. Laboratory to cure concrete cylinders conforming to ASTM C192/C192M.
3. Cylinders shall be tested conforming to ASTM C39/C39M. Average strength of two (2) 6-inch diameter cylinders or three (3) 4-inch diameter cylinders of same age shall be used as result of the test. Break two (or three) cylinders at 7 days and two (or three) at 28 days. Maintain two (or three) cylinders for backup and/or testing at 56 days (if required). Remaining two (or three) cylinders may be discarded after 28 days if 28-day testing results are acceptable.
4. Testing laboratory shall document testing results and distribute to Engineer, Owner, and Contractor.

3.05 LOW-STRENGTH CONCRETE:

A. Defined as concrete whose 7-day and 14-day compressive test (average of two 6-inch diameter or three 4-inch diameter cylinders) is less than 70% and 85%, respectively, of the design required minimum 28-day compressive strength.
B. Disposition of Concrete:
1. Concrete shall remain accessible with no other Work performed that relates to or depends upon the questionable concrete until a final decision as to the disposition of the concrete is given by Engineer.
2. Low-strength concrete shall be removed and replaced if requested by Engineer.

3.06 PLACING OF CONCRETE:

A. Preparation:
1. Clean bonding surfaces to be free from laitance and foreign materials.
2. Verify that all embedded items are accurately and securely installed. Embedded items shall be securely fixed in place to prevent flotation/movement during concrete placement.
3. Place concrete on properly prepared and unfrozen subgrade and only in dewatered excavations.
4. Do not deposit partially hardened concrete or concrete contaminated by foreign materials.

B. Placing Concrete:
1. Conform to ACI SPEC 301 and ACI PRC 304.

2. Place within 90 minutes after start of mixing or within 300 revolutions of mixing drum, except place within 60 minutes after start of mixing if ambient temperature will exceed 90°F (32°C) during placement.
3. Place in horizontal layers not exceeding 18 inches.
4. Consolidate concrete by mechanical means in accordance with ACI PRC 309 as necessary to produce solid mass of well distributed cement paste and aggregate without honeycomb or surface air bubbles.

C. Curing Concrete:
1. Conform to ACI SPEC 301 and ACI SPEC 308.1.
2. Cure with liquid-membrane forming curing compound conforming to ASTM C309. Apply according to manufacturer's recommendations.
3. Apply curing compound to all exposed surfaces immediately after removing form or after finishing concrete.
4. Keep formwork wet until stripped.

3.07 HOT WEATHER CONCRETING:

A. Follow the recommendations of ACI PRC 305 if any of the following conditions occur:
1. When the ambient temperature is 90°F (32°C) or above.
2. When the temperature is likely to rise above 90°F (32°C) within the 24-hour pierod after concrete placement.
3. When there is any combination of high air temperature, low relative humidity, and wind velocity which would impair either concrete strength or quality.

B. Concrete shall have a maximum temperature of 85 degrees F during placement.

C. Protect freshly placed concrete immediately after placement so that the rate of evaporation as determined by ACI SPEC 305.1 does not exceed 0.2-pound per square foot per hour.

D. Begin curing formed and unformed surfaces immediately after finishing and continue for 24 hours.

3.08 COLD WEATHER CONCRETING:

A. Follow the recommendations of ACI SPEC 306.1 and ACI PRC 306 if any of the following conditions occur:
1. The temperature is 40°F (4°C) or is likely to fall below 40°F (4°C) during the 24-hour period after concrete placement..

B. Minimum temperature for concrete as mixed shall be as indicated in Table 5.1 of ACI PRC 306. Maximum temperature for concrete as mixed shall be 15 degrees F greater than the corresponding minimum temperature.

C. Do not expose concrete to carbon monoxide or carbon dioxide fumes from heaters or engines. Oil or coke burning salamanders will not be permitted. Personnel shall be present at all times to maintain safe, continuous operation of heating system.

D. Control temperature and humidity of protected concrete so that excessive drying of concrete surfaces does not occur.

E. Calcium chloride will not be permitted as a concrete accelerator or to thaw frozen subgrade prior to concrete placement.

3.09 JOINTS:

A. Locate joints where indicated. Conform to ACI CODE 318.

B. Construction Joints:

1. Clean and break laitance or other foreign material from bonding surface. Apply bonding agent in accordance with manufacturer's recommendations prior to next placement of concrete.
2. Provide waterstops in construction joints where indicated. Install conforming to manufacturer's printed instructions. Maintain a minimum of 1-1/2-inch clear between waterstops and formwork, rebar, and other embedded items.

C. Expansion Joints:
1. Install filler, backer rod, and sealant in strict conformance with manufacturer's printed instructions.
2. Install joint sealants to conform to ASTM C1193. Tool sealants to provide smooth, uniform bead with a slightly concave surface, eliminate air pockets, and ensure sealant contact and adhesion with sides of joints.

D. Contraction Joints:
1. Saw cut or tool contraction joints were indicated. Maintain true alignment with a straightedge.
2. Tooled contraction joints shall be installed during the finishing process and shall be maximum of 1/4-inch in width and depth of at least 1-inch.
3. Saw-cut contraction joints shall be made with a power blade as soon as concrete surface is firm enough to resist tearing or damage by the blade and before random shrinkage cracks can occur (usually 4-12 hours after finishing). Use early-entry saw as required.

3.10 SURFACE FINISHES:

A. Screed Finish:
1. Use as a first stage for all concrete finishes.
2. Immediately after screeding, use a float, darby, or bullfloat to eliminate high and low spots and to embed large aggregate. This shall be done in a manner to produce even, uniform surfaces so that surface irregularities do not exceed 3/8-inch in 10 feet.

B. Floated Finish:
1. Use as a second stage of broomed or troweled finish.
2. Float with a mechanical float. Hand floating will be permitted only in areas inaccessible to mechanical float.
3. On surfaces not to receive troweled finish, finish with wood or cork float after mechanical floating to a true uniform surface so that surface irregularities do not exceed 1/8-inch in 10 feet.

C. Broomed Finish:
1. Use as a final finish on all outdoor slabs including pavements, sidewalks, and door stoops.
2. After floated finish, draw a stiff bristled broom across the surface making uniform corrugations, perpendicular to the direction of traffic, note more than 1/16-inch deep.

D. Hard-Troweled Finish:
1. Finish surface as in "Float Finish" and in addition, trowel with steel trowel to obtain a smooth dense finish after concrete has hardened to ring under the trowel.
2. Use this finish on all interior floors and slabs not specifically designated for a different finish.

E. Burlap Finish:
1. Apply burlap surface treatment to exposed edges of slabs, curbs, and foundations after concrete has reached initial cure and within 3 days of formwork removal.
2. Wet and fill all voids using mortar of the same sand-cement ratio and color as original concrete or pre-packaged manufactured surfacing mortar.

3. Strike off excess mortar flush with the surfae using a burlap or canvas cloth with a circular motion.
4. Remove all rough spots and rub with cloth to leave a surface of uniform texture and appearance.
5. Finish shall result in a coating of mortar that will fill all small voids, air holes, and surface imperfections, leaving a smooth surface.
6. Cure as specified in PART 3, Article 3.06 – PLACING OF CONCRETE

F. Defective Surface Treatments:
1. After removal of forms, remove all fins, projections, and form ties.
2. Grout and cure all voids, damaged areas, and tie holes.

3.11 REPAIR, REPLACEMENT, AND FIELD MODIFICATIONS:

A. Embedded items and concrete that are misplaced or damaged during construction shall not be repaired, replaced, or field-modified without approval of Engineer.

END OF SECTION 03 30 50

SECTION 09 90 00 – PROTECTIVE COATINGS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and DIVISION 01 Specification Sections, apply to this Section.

1.02 SUMMARY:

A. This Section includes coating of exterior and interior surfaces throughout the Project and which are listed in PART 2, with systems specified on "coating system" sheets at the end of this Section.

B. Coating systems include surface preparation, prime coat (first coat), finish coats (second and third coats), inspection, cleaning, and touch-up of surfaces and equipment. Shop preparation, prime coat, and finish coats to be shop-applied, may be specified elsewhere or referenced to this Section so that a complete system is specified and coordinated.

C. Where surface preparation and first (prime) coat are specified in other Sections to be shop-applied, such as for structural steel, hollow metal doors or equipment, only the touch-up and finish coats are a part of field painting. Surface preparation is the required degree of preparation prior to application of first (prime) coat regardless of if done in shop or field.

1. If materials are provided without shop primer such as miscellaneous steel or sheet metal, then surface preparation, first, second, and third coats are a part of field painting.

1.03 RELATED REQUIREMENTS:

A. Shop Painting and Coatings: All applicable Divisions.

B. Factory Prefinished Items: All applicable Divisions.

1.04 REFERENCE STANDARDS:

A. Applicable Standards:

1. American National Standards Institute (ANSI):
   a. A13.1 - Scheme for the Identification of Piping Systems.
   b. Z53.1 - Safety Color Code for Marking Physical Hazards.
2. ASTM International (ASTM):
   a. D4259 - Abrading Concrete.
3. Society for Protective Coatings (SSPC) Surface Preparation Specifications:
   a. SP1 - Solvent Cleaning: Removes oil, grease, soil, drawing and cutting compounds, and other soluble contaminants.
   b. SP2 - Hand Tool Cleaning: Remove loose material. Not intended to remove adherent mill scale, rust, and paint.
   c. SP3 - Power Tool Cleaning: Removes loose material. Not intended to remove all scale or rust.
   d. SP5 - White Metal Blast Cleaning: Removes all scale, rust, foreign matter. Leaves surface gray-white uniform metallic color.
   e. SP6 - Commercial Blast Cleaning: Two-thirds of every nine square inches free of all visible residues; remainder only light discoloration.
   f. SP10 - Near-White Blast Cleaning: At least 95% of every nine square inches shall be free of all visible residues.
   g. SP11 - Power Tool Cleaning to Bare Metal.
   h. SP13 – Surface Preparation of Concrete.

1.05 SUBMITTALS:

A. Submit as specified in DIVISION 1.
B. Includes, but not limited to, the following:
   1. Schedule of products and paint systems to be used. Schedule shall include the following information:
      a. Surfaces for system to be applied.
      b. Surface preparation method and degree of cleanliness.
      c. Product manufacturer, name, and number.
      d. Method of application.
      e. Dry film mil thickness per coat of coating to be applied.
   2. Color charts for selection and acceptance.
   3. Technical and material safety data sheets.
   4. Certification(s) by coating manufacturer(s) that all coatings are suitable for service intended as stated on each coating system sheet. If manufacturer has an equivalent product as that specified, and it is suitable for the intended purpose, Contractor shall submit the recommended product for approval at no increase in cost, and state reasons for substitution.
   5. Contractor shall certify in writing to the Engineer/Architect that applicators have previously applied all the systems in this Specification and have the ability and equipment to prepare the surfaces and apply the coatings correctly.
C. Submittals for industrial maintenance coatings shall be prepared by, or have assistance in preparation of, a corrosion engineer or industrial coatings technical representative of the coating manufacturer.

1.06 QUALITY ASSURANCE:

A. Include on label of container:
   1. Manufacturer's name, product name, and number.
   2. Type of paint and generic name.
   3. Color name and number.
   4. Storage and temperature limits.
   5. Mixing and application instructions, including requirements for precautions which must be taken.
   6. Drying, recoat, or curing time.
B. A coating report shall be completed daily by Contractor at each phase of the coating system starting with surface preparation. These shall be submitted on the form attached at end of this Section.
C. In the event a problem occurs with coating system, surface preparation, or application, Contractor shall require coating applicator and coating manufacturer's technical representative to promptly investigate the problem and submit results to Engineer/Architect.

1.07 DELIVERY, STORAGE, AND HANDLING:

A. Delivery of Materials:
   1. Deliver in sealed containers with labels and information legible and intact. Containers shall also have correct labels with required information.

1.08 REGULATORY REQUIREMENTS:

A. In addition to requirements specified elsewhere for environmental protection, provide coating materials that conform to the restrictions of the U.S. EPA and the local and regional jurisdictions. Notify Engineer/Architect of any coating specified herein that fails to conform to the requirements for the location of the Project or location of application.
B. Lead Content: Use only coatings that are totally lead free.
C. Chromate Content: Do not use coatings containing zinc-chromate or strontium chromate.

D. Asbestos Content: Materials shall not contain asbestos.
E. Mercury Content: Materials shall not contain mercury or mercury compounds.

1.09 WARRANTY
A. The Manufacturer shall warrant that all protective coatings shall be free from defects caused by faulty material or workmanship for a minimum period of one (1) year from the date of Substantial Completion, unless otherwise specified.
B. Warranties shall comply with the requirements of Division 01.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS:
A. Proprietary names and product numbers are specified in most systems for material identification from these manufacturers:
B. PPG Industries.
1. Carboline Company, Inc.
2. Tnemec Company, Inc.
3. Sherwin-Williams.

2.02 GENERAL:
A. Materials furnished for each coating system must be compatible to the substrate.
B. When unprimed surfaces are to be coated, entire coating system shall be by the same coating manufacturer to assure compatibility of coatings.
C. When shop-painted surfaces are to be coated, ascertain whether finish materials will be compatible with shop coating. Inform Engineer/Architect of any unsuitable substrate or coating conditions.
D. All coatings in contact with raw, partially treated, or treated potable water must be NSF 61 product certified, as applicable. NSF 61 product certification must be valid at the time of construction. Starting January 1, 2023, in order to be NSF 61 product certified, coatings and finishes must meet the most current health effects criteria of NSF 600 for xylenes, toluene, and ethylbenzene.

2.03 COATING SYSTEMS:
A. Specified on the "Protective Coating System" sheets at the end of this Section.

2.04 SURFACES TO BE COATED:
A. System A-5:
1. Item: exterior exposed carbon steel
a. Reference: SECTION 46 41 41 – Carbon System Mixers
b. Location: As indicated
B. System D-1:
1. Item: Process equipment and pipe submerged in potable water, including: pump/motor interiors.
a. Reference: DIVISION 46
b. Location: As indicated
C. Item: Existing Exterior Steel/CMU/Concrete
1. Provide the following Tnemec system or Architect approved equal meeting the design criteria below.
a. Fully protect, mask and seal off everything in the area that will not receive the coating system.

b. Surface Preparation: High-pressure water blast all areas with a minimum 2000 lbs. psi at the tip at a rate of 3 – 5 gallons/minute, utilizing an orbital tip and TSP detergent additive to remove chalk, loose paint and other contaminants, followed by a clean water rinse.
c. Test patch: A test past shall be applied to the substrate to determine adhesion is adequate for overcoats.
d. Prime coat with Tnemec Series 108 Probond @ 1.5 - 2.0 mils DFT.
e. Finish Coat - Tnemec Series 297 Enviro-Glaze @ 2.0 - 3.0 mils DFT.

D. Item: PAC Silo
1. Provide the following Tnemec system or Architect approved equal meeting the design criteria below. All painting of silos and other equipment and assocated silo appurtenances integral to the PAC feeding system shall be done at the silo manufacturing site. Equipment Supplier shall provide touch up paint to the Contractor for field touch up. The Equipment Supplier shall prepare all painted surfaces of the silo as follows:
a. All interior steel surfaces of the silo (except where insulated):
(1) Surface Preparation: In accordance with SSPC-SP10/NACE 2 Near White metal cleaning and approved materials removal and containment plan. Clean and dry surface per ASTM D4258.
(2) Primer: Series V69 Hi-Build Epoxoline II @ 4.0-6.0 mils
(3) Stripe: Series V69 Hi-Build Epoxoline II @ 2.0-4.0 mils
(4) Finish Coat: Series V69 Hi-Build Epoxoline II @ 4.0-6.0 mils
b. Insulation interior surface:
(1) Surface Preparation: Clean and dry
(2) Primer: Series 151-1051 Elasto-Grip FC @ 0.7-1.5 mils D.F.T.
(3) Finish Coat: 1 coat of Series V69 Hi-Build Epoxoline II @ 4.0-8.0 mils D.F.T.
Total D.F.T. of 6.5-11.0 mils minimum.
c. All exterior surfaces of the silo:
(1) Surface Preparation: In accordance with SSPC-SP10/NACE 2 near White metal. Clean and dry surface per ASTM D4258.
(2) Primer: Series 90-97 Tneme-Zinc @ 2.5-3.5 mils
(3) Intermediate Coat: Series V69 Hi-Build Epoxoline II @ 4.0-6.0 mils
(4) Finish Coat: Series 1095 Endura-Sheild @ 2.0-3.0 mils D.F.T.
Total D.F.T. of 6.5-9.5 mils minimum.
2. All surfaces of the silo shall be touch-up painted in the field by the installation contractor.
3. All equipment other than the silo shall be painted with the Supplier's standard paint system.

2.05 SURFACES NOT TO BE COATED:

A. Do not field coat any of the following items unless specifically noted otherwise.
1. Copper, stainless steel, aluminum, FRP fabrications, Conduit, PVC piping.

2.06 COLOR CODING OF PHYSICAL HAZARDS:

A. Color Coding Physical Hazards: Exterior and interior.
1. General:
a. Paint areas indicated to identify physical hazard areas as required by ANSI Z53.1.
b. All colors shall conform to Federal Safety Color Code requirements.

PART 3 - EXECUTION

3.01 SURFACE PREPARATION:

A. Prepare surfaces for each coating system conforming to SSPC or ASTM surface preparation specifications listed.
   1. If grease or oils are present, SSPC-SP1 shall precede any other method specified for metal substrates.
   2. Remove surface irregularities such as weld spatter, burrs, or sharp edges prior to specified surface preparation.
B. Depth of profile will be as specified or as recommended by the manufacturer for each system, but in no instance shall it exceed one-third of the total dry film thickness of complete system.
C. Prepare only those areas which will receive the first coat of the system on the same day.
   1. On steel substrates, apply coating before rust bloom forms.

3.02 APPLICATION:

A. Apply coatings in accordance with coating manufacturer's recommendations.
B. Use properly designed brushes, rollers, and spray equipment for all applications.
C. On unprimed surfaces apply first coat of the system the same day as surface preparation.
D. Dry film thickness of each system shall meet the minimum specified. Maximum dry film thickness shall not exceed the minimum more than 20% or coating manufacturer's requirements if less. Where a dry film thickness range is specified, the range shall not be less than or exceeded.
E. Shop and field painting shall remain 3 inches (75mm) away from unprepared surface of any substrate such as areas to be welded or bolted.
F. Environmental Conditions:
   1. Atmospheric temperature must be 50ºF (10ºC) or higher during application, unless otherwise approved by coating manufacturer. Do not apply coatings when inclement weather or freezing temperature may occur within coating recoat cure times.
   2. Wind velocities for exterior applications shall be at a minimum to prevent overspray or fallout and not greater than coating manufacturer's limits.
   3. Relative humidity must be less than 85%. The ambient temperature and the temperature of the surface to be painted must be at least 5ºF (2.8ºC) above the dew point.
   4. Provide adequate ventilation in all areas of application to ensure that at no time does the content of air exceed the Threshold Limit Value given on the manufacturer's Material Safety Data Sheets for the specific coatings being applied.
G. Recoat Time: In the event a coating, such as an epoxy, has exceeded its recoat time limit, prepare the applied coating in accordance with manufacturer's recommendations.
H. Protection:
   1. Cover or otherwise protect surfaces not to be painted. Remove protective materials when appropriate.
   2. Mask, remove, or otherwise protect finish hardware, machined surfaces, grilles, lighting fixtures, and prefinished units as necessary.
   3. Provide cover or shields to prevent surface preparation media and coatings from entering orifices in electrical or mechanical Equipment. Where ventilation systems must be kept in operation at time of surface preparation, take precautions to shield intakes and exhausts to prevent the materials from entering system or being dispersed.
   4. Provide signs to indicate fresh paint areas.
   5. Provide daily cleanup of both storage and working areas and removal of all paint refuse, trash, rags, and thinners. Dispose of leftover containers, thinners, rags, brushes, and rollers which cannot be reused in accordance with applicable regulations.
   6. Do not remove or paint over Equipment data plates, code stamps on piping, or UL fire-rating labels.

3.03 INSPECTION:

A. Contractor shall provide and use a wet film gauges to check each application approximately every 15 minutes in order to immediately correct film thickness under or over that specified.
B. Contractor shall provide and use a dry film gauge to check each coat mil (mm) thickness when dry, and the total system mil (mm) thickness when completed.
C. Use holiday or pinhole detector on systems over metal substrates to detect and correct voids when indicated on system sheet.
D. Check air temperature and temperature of the substrate at regular intervals to be certain surface is 5°F (2.8°C) or more above the dew point.
    1. Thickness and Holiday Testing (Steel Surfaces): Thickness of coatings shall be checked with a non-destructive, magnetic-type thickness gauge. Use an instrument such as a Tooke Gauge if a destructive tester is deemed necessary. The integrity of coated surfaces shall be checked with an approved inspection device. Non-destructive holiday detector shall not exceed the voltage recommended by the Manufacturer of the coating system. For thickness between 10 and 20 mils, use a non-sudsing type wetting agent, such as Kodak Photo-Flow. Failures shall be marked, repaired in accordance with the Manufacturer's printed recommendations and retested. No pinholes or other irregularities will be permitted in the final coating.
    Inspection Devices: The Contractor shall furnish, until final acceptance of coating and painting, inspection devices in good working condition for detection of holidays and measurement of dry film thickness (dft) of coating. The Contractor shall also furnish U.S. Department of Commerce; National Bureau of Standards certified thickness calibration plates to test accuracy of dft gauges and certified instrumentation to test accuracy of holiday detector. Dry film thickness gauges and holiday detectors shall be made available for the Owner and Engineer/Architect's use at all times until final acceptance of application. Holiday Detection devices shall be operated in the presence of the Engineer or Architect.

3.04 CLEANING AND REPAIRS:

A. Remove spilled, dripped, or splattered paint from surfaces.
B. Touch up and restore damaged finishes to original condition. This includes surface preparation and application of coatings specified.
C. Provide remainder of open paint cans to owner for touch ups.

END OF SECTION 09 90 00

COATING REPORT

Contract Name: _____ Contract No.: _____
Coating Contractor: _____ Foreman: _____

Unit or Surface Identification: _____
Unit or Surface Location: Exterior: _____, Interior: _____

Surface Preparation:
Date _____; Air Temp _____°F; Relative Humidity _____%
Method of Surface Preparation: _____
Profile achieved _____ mils (if applicable).

Touch-Up:
Date _____; Time _____; Air Temp _____°F; Surface Temp _____°F
Relative Humidity _____%; Dew Point _____°F
Coating Used _____; Dry Film Obtained _____mils.

First Coat:
Date _____; Time _____; Air Temp _____°F; Surface Temp _____°F
Relative Humidity _____%; Dew Point _____°F
Coating Used _____; Dry Time Before Recoat _____ hrs.
Dry Film Obtained _____ mils.

Second Coat:
Date _____; Time _____; Air Temp _____°F; Surface Temp _____°F
Relative Humidity _____%; Dew Point _____°F
Coating Used _____; Dry Time Before Recoat _____ hrs.
Dry Film Obtained _____ mils.

Third Coat:
Date _____; Time _____; Air Temp _____°F; Surface Temp _____°F
Relative Humidity _____%; Dew Point _____°F
Coating Used _____; Dry Film Obtained _____mils.

BURNS McDONNELL	PROTECTIVE COATING SYSTEM **System: A-5**

SERVICE:	Steel - Moderate to Severe Exposure (Nonimmersion)
Surface Preparation:	Shop: SSPC-SP6 and profile depth 1.5 to 2.5 mils (38 to 63 microns). Field: SSPC-SP2/3. Clean and dry.
First Coat:	High solids polyamine or polyamide epoxy with minimum 67% solids by volume. Apply at 5.0 to 7.0 mils (125 to 175 microns) dry film thickness.
Second Coat:	High solids aliphatic acrylic polyurethane gloss enamel with minimum 52% solids by volume. Apply at 3.0 to 5.0 mils (75 to 125 microns) film thickness.
System Total:	Minimum 8.0 mils (200 microns) dry film thickness.
Volatile Organic Content:	Maximum 2.8 lb/gal (340 g/L)

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COATING MANUFACTURER	PRODUCT DESIGNATION		
	FIRST COAT	**TOUCH UP**	**SECOND COAT**
PPG	Amerlock 2 or 400	Same as first coat	Amercoat 450 H
Carboline	Carboguard 890	Same as first coat	Carbothane 134 HG
Tnemec	Hi-Build Epoxoline II, Series N69	Same as first coat	Endura-Shield, Series 1094
Sherwin-Williams	Macropoxy 646 B58-600/B58V600	Same as first coat	HS Polyurethane B65-300 Series

BURNS McDONNELL	PROTECTIVE COATING SYSTEM **System: B-4**

SERVICE:	Nonferrous & Galvanized Metal — Moderate to Severe Exposure Exterior or Interior (Including Galvanized Handrail)
Surface Preparation:	Shop or field first coat: Remove oil or soap film with neutral detergent or emulsion cleaner.
First Coat:	Pretreat and/or allow to weather as recommended by coating manufacturer.
Second Coat:	High build polyamide or polyamidoamine epoxy with minimum 65% solids by volume. Apply at 4.0 - 6.0 mils (100 -150 microns) dry film thickness.
Third Coat:	High solids aliphatic acrylic polyurethane gloss enamel with minimum 60% solids by volume. Apply at 2.0 – 3.0 mils (50 – 75 microns) dry film thickness.
System Total:	Minimum 6.0 mils (150 microns) dry film thickness in addition to galvanizing.
Volatile Organic Content:	Maximum 2.8 lb/gal (340 g/L).

COATING MANUFACTURER	PRODUCT DESIGNATION			
	FIRST COAT	**TOUCH UP**	**SECOND COAT**	**THIRD COAT**
PPG	See above		Amercoat 385	Amercoat 450 H
Carboline	See above		Carboguard 893 SG	Carbothane 134 HG
Sherwin-Williams	See above		Macropoxy 646 B58-600 Series	HS Polyurethane B65-300 Series
Tnemec	See above		F.C. Typoxy Series 27	Endura-Shield 1094

BURNS McDONNELL	PROTECTIVE COATING SYSTEM **System: D-1**

SERVICE: Steel: Potable Water Immersion, Normal Service, Interior of Tank.

Surface Preparation: Shop or Field First Coat: SSPC-SP10 and profile depth of 1.5 to 2.5 mils (38 to 63 microns).
Field Touch-Up (of Shop-applied first coat): Same as for first coat.

First Coat: High solids epoxy phenalkamine coating with minimum 82% solids by volume and be for use with potable water that is NSF 61 product certified including Standard 600. Apply at 12.0 to 18.0 mils (305 to 457 microns) dry film thickness.

Second Coat: None.

System Total: Minimum 12.0 mils (305 microns) dry film thickness. Check for voids with holiday or pinhole detector.

COATING MANUFACTURER	PRODUCT DESIGNATION		
	FIRST COAT	**TOUCH UP**	**SECOND COAT**
Tnemec	Epoxoline, Series 21	Same as first coat	

BURNS McDONNELL

PROTECTIVE COATING SYSTEM

System: E-1

SERVICE: Steel & Iron – Nonpotable Liquid Immersion, Normal to Severe Exposure. Interior of Tank or Basin. Exterior of Steel, Piping, or Equipment in Tank or Basin.

Surface Preparation: Shop or Field First Coat: SSPC-SP10 and profile depth of 1.5 to 2.5 mils (38 to 63 microns).
Field Touch-Up (of Shop-applied first coat): Same as for First Coat.

First Coat: High solids amine, polyamidoamine, or polyamide epoxy coating with minimum 67% solids by volume. Apply at 5.0 to 7.0 mils (125 to 175 microns) dry film thickness.

Second Coat: Same as first coat.

System Total: Minimum 10.0 mils (250 microns) dry film thickness. Check for voids with holiday or pinhole detector.

Volatile Organic Content: Maximum 2.8 lb/gal (340 g/L).

COATING MANUFACTURER	PRODUCT DESIGNATION		
	FIRST COAT	**TOUCH UP**	**SECOND COAT**
PPG	Amerlock 2 or 400	Same as first coat	Same as first coat
Carboline	Carboguard 890	Same as first coat	Same as first coat
Sherwin-Williams	Macropoxy 646 FC B58W610/B58V600	Same as first coat	Same as first coat
Tnemec	Hi-Build Epoxoline II Series V69	Same as first coat	Same as first coat

BURNS McDONNELL	PROTECTIVE COATING SYSTEM **System: L-4**

SERVICE: Fiberglass-Reinforced (FRP) and Polyvinyl Chloride (PVC) Piping – Interior/Exterior Exposure (Nonimmersion)

Surface Preparation: Field First Coat: Sand lightly. Clean and dry.

First Coat: High build polyamide epoxy with minimum 50% solids by volume. Apply at 4.0 to 6.0 mils (100 to 150 microns) dry film thickness.

Second Coat (Interior): None required.

Second Coat (Exterior: High solids aliphatic acrylic polyurethane gloss enamel with minimum 52% solids by volume. Apply at 2.0 to 3.0 mils (50 to 75 microns) dry film thickness.

System Total: Interior: Minimum 4.0 mils (100 microns) dry film thickness.
Exterior: Minimum 6.0 mils (150 microns) dry film thickness.

Volatile Organic Content: Maximum 3.5 lb/gal (425 g/L)

COATING MANUFACTURER	PRODUCT DESIGNATION	
	FIRST COAT	**SECOND COAT EXT.**
PPG	Amercoat 2 or 400	Amercoat 450 H
Carboline	Carboguard 893 SG	Carbothane134 HG
Ceilcote	650FDA Ceilgard	477 Ceilgard
International	Intergard 475 HS	Interthane 990 Series
ITW Devcon Futura	Flexshield Primer 4484	Flexshield 1000
Sherwin-Williams	Macropoxy 646 B58 W600 Series	Acrolon 218 HS B65-600 Series
Tnemec	Hi-Build Epoxoline II Series V69	Endura-Shield II - Series 1094

DIVISION 26 - ELECTRICAL

SECTION 26 00 00 – GENERAL ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.01 SUMMARY:

A. This SECTION includes requirements for electrical Work by this Contract.

B. The following administrative and procedural requirements are included in this SECTION to expand the requirements specified in DIVISION 01:
   1. Submittals.
   2. Coordination drawings.
   3. Record documents.
   4. Maintenance manuals.
   5. Rough-ins.
   6. Electrical installations.
   7. Electrical demolition.
   8. Cutting and patching.
   9. Touch-up painting.

C. Install and make suitable for operation equipment furnished by others per the Drawings and Specifications.

D. Provide Equipment as specified in Division 26.

E. Furnish and install Material for electrical equipment and systems; including supports, conduit, fittings, wiring and connectors.

F. Furnish all Labor and Materials to complete the Work as specified in accordance with national, state and local governing bodies having jurisdiction.

G. All Equipment and Material shall be rated for the Project Site conditions as specified in DIVISION 01.

H. Provide all temporary construction power and lighting.

I. Provide skilled labor and technical assistance to manufacturer's service representatives for the configuration and startup of electrical Equipment and Systems.

J. Perform Work in the following locations at the Project Site:
   1. PAC Pretreatment Facility.
   2. West Gravel Lakes Pump Station.
   3. Sludge Lagoon Effluent.

K. Coordinate Work with others as specified in this SECTION PART 3 - EXECUTION. Provide seven days' notice to the Engineer and Owner before interruption to existing electrical service, including:
   1. Utility power
   2. Generator sets
   3. Emergency lighting
   4. Fire-alarm systems

1.02 RELATED REQUIREMENTS:

A. DIVISION 01 - General Requirements.

B. DIVISION 03 - Concrete.

C. DIVISION 08 - Openings.

D. SECTION 09 90 00 - Protective Coatings

E. DIVISION 23 - Heating, Ventilating, and Air Conditioning (HVAC).

F. SECTION 26 05 19 - Low-Voltage Conductors and Cables

G. SECTION 26 05 26 - Grounding and Bonding for Electrical Systems

H. SECTION 26 05 29 - Hangers and Supports for Electrical Systems
I. SECTION 26 05 33 - Raceway and Boxes for Electrical Systems
J. SECTION 26 05 43 - Underground Ducts and Raceways for Electrical Systems
K. SECTION 26 05 44 - Sleeves and Sleeve Seals for Electrical Raceways and Cabling
L. SECTION 26 05 53 - Identification for Electrical Systems
M. SECTION 26 05 73 - Short-Circuit, Coordination and Arc-Flash Hazard Analysis Studies
N. SECTION 26 22 13 - Low Voltage Distribution Transformers
O. SECTION 26 24 16 - Panelboards
P. SECTION 26 43 13 - Surge Protective Devices for Power Distribution and Point-of-Service Equipment
Q. DIVISION 31 - Earthwork
R. SECTION 40 60 00 - Process Control and Instrumentation General Requirements
S. SECTION 40 61 96 - Process Control Descriptions
T. SECTION 40 66 00 - Process Control Networks
U. SECTION 40 67 00 - Control System Equipment Panels
V. SECTION 40 68 00 - Process Control Software
W. SECTION 40 70 00 - Instrumentation For Process Systems
X. SECTION 46 05 13 - Common Motor Requirements for Water and Wastewater Equipment.

1.03 REFERENCE STANDARDS:

A. Publication Dates: Comply with standards in effect as of the Issued For Construction (IFC) date of the Contract Documents unless otherwise indicated.
B. American National Standards Institute (ANSI)
C. ASTM International (ASTM)
D. Federal Information Processing Standards Publication (FIPS)
E. Insulated Cable Engineer's Association (ICEA)
F. Institute of Electrical and Electronic Engineers (IEEE)
G. National Electrical Contractors Association (NECA)
H. National Electric Manufacturers Association (NEMA)
I. National Electrical Installation Standards (NEIS)
J. National Fire Protection Association (NFPA)
    1. National Electrical Code (NFPA 70)
    2. Standard for Electrical Safety in the Workplace (NFPA 70E)
K. Telecommunications Industry Association (TIA)
L. Underwriter's Laboratories, Inc (UL)

1.04 DEFINITIONS:

A. Definition:
    1. Direct Buried: Installed underground without encasement in concrete or other protective material.
    2. Enclosure: The case or housing of an apparatus, or the fence or wall(s) surrounding an installation, to prevent personnel from accidentally contacting energized parts or to protect the equipment from physical damage. Types of enclosures and enclosure covers include the following:

a. Cabinet: An enclosure that is designed for either surface mounting or flush mounting or pad mounting. Cabinet is provided with a frame, mat, or trim in which a swinging door or doors are or can be hung.
b. Conduit Body: A means for providing access to the interior of a raceway system through one or more removable covers at an outlet, conduit box or terminal point.
c. Conduit Box: A box having threaded openings or knockouts for conduit, flexible metal tubing, or fittings.
d. Device Box: A box with provisions for mounting a wiring device directly to the box.
e. Floor-Mounted Enclosure: A floor box and floor box cover assembly with means to mount in the floor that is sealed against the entrance of scrub water at the floor level.
f. Floor Nozzle: An enclosure used on a wiring system, intended primarily as a housing for a receptacle, provided with a means, such as a collar, for surface-mounting on a floor, which may or may not include a stem to support it above the floor level, and is sealed against the entrance of scrub water at the floor level.
g. Junction Box: A box with a blank cover that joins different runs of raceway or cable and provides space for connection and branching of the enclosed conductors.
h. Outlet Box: A box that provides access to a wiring system having pryout openings, knockouts, threaded entries, or hubs in either the sides or the back, or both, for the entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting an outlet box cover, but without provisions for mounting a wiring device directly to the box.
i. Pull Box: A box with a blank cover that joins different runs of raceway and provides access for pulling or replacing the enclosed cables or conductors.
j. Raised-Floor Box: A floor box intended for use in raised floors.
k. Termination Box: An enclosure designed for installation of termination base assemblies consisting of bus bars, terminal strips, or terminal blocks with provision for wire connectors to accommodate incoming or outgoing conductors, or both.

3. Luminaire: A complete lighting unit consisting of a light source such as a lamp, together with the parts designed to position the light source and connect it to the power supply. It includes the parts to protect the light source and the driver to connect to the light source power supply.
4. Plenum: A compartment or chamber to which one or more air ducts are connected and that forms part of the air distribution system.
5. Receptacle: A fixed connecting device arranged for insertion of a power cord plug. Also called a power jack.

1.05 SUBMITTALS:

A. Submit as specified in DIVISION 01.
B. Refer to each Section of this Division for specific Product Data, Shop drawing and additional Submittal requirements.
C. Product Data, manufactured equipment:
   1. Include data specification sheets, equipment cut sheets, outline drawings, electrical equipment ratings for pressure temperature and voltage.
D. Shop Drawings, fabricated equipment:

1. Include fabrication drawings, connection point size, type, and rating, field wiring and ratings for pressure, temperature, power, current and voltage.
2. Clearly specify any components not provided with requirement required for safe and proper operating of equipment.

E. Coordination Drawings: in accordance with DIVISION 01, for equipment rooms, and other congested areas to a scale of 1/4 inch=1 foot-0 inch or larger if required. Detail major electrical Systems, Equipment and Material indicated on floor plans and section detail. Check for interferences with architectural, structural or mechanical systems, installations, and building components. Do not allow mechanical systems where plumbing or water systems are installed above electrical systems. Drawings shall indicate where space is limited for installation, maintenance access, working clearances. Drawings shall indicate where sequencing and coordination of Work is important for efficient flow of the Work and to reduce any rework. At a minimum include:
1. Elevation size and route of cable trays and raceways.
2. Relationships and clearance distances between components and adjacent architectural, structural, electrical, and mechanical elements.
3. Working clearances for equipment, including space for equipment disassembly required for periodic maintenance.
4. Exterior wall and foundation penetrations.
5. Fire-rated wall and floor penetrations.
6. Equipment connections and support details.
7. Size and location of concrete pads, footers and bases.
8. Support details.
9. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
10. Elevations, sizes of sleeves to indicate penetrations in floors, walls, and ceilings, and their relationship to other penetrations and installations.
11. Elevation of ceilings and ceiling components to coordinate and integrate installations, air outlets, air inlets, light fixtures, communications systems' components, sprinklers, heat detectors, smoke detectors, motion detectors, speakers, access panels and other ceiling-mounted devices.
12. Coordinate chases, slots, inserts, sleeves, and openings with electrical equipment. In general verify all panel connections align with .

F. As-Built Records:
1. Redline all Contract Drawings and Shop Drawings to indicate changes after Issued For Construction (IFC) set of drawings.
2. Include:
   a. Major raceway systems, size and location for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; disconnects, fuse size and location, circuit breaker sizes and arrangements.
   b. Equipment locations dimensioned from prominent building lines.
   c. Approved substitutions, Contract Modifications, and actual equipment and materials installed.
3. Including changes resulting from:
   a. Requests for Information (RFI).
   b. Purchase Change Orders (PCO).
   c. Engineering Change Notices (ECN).

d. Requests for substitution or alternate products.

G. Operation and Maintenance (O&M) manuals: in accordance with SECTION 01 78 00 - Contract Closeout. In addition to the requirements specified in DIVISION 01, include the following:
   1. Description of function, normal operating characteristics and limitations, performance curves, engineering data, tests, and complete nomenclature and commercial numbers of replacement parts.
   2. Manufacturer's printed operating procedures to include start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; lockout/tagout procedures; and summer and winter operating instructions.
   3. Maintenance procedures for routine preventive maintenance and troubleshooting; disassembly, repair, reassembly; aligning and adjusting instructions.
   4. Product Data
   5. Shop Drawings
   6. Servicing instructions, lubrication charts and schedules.
   7. As-Built Records.

H. Field quality-control reports.

1.06 QUALITY ASSURANCE:

A. As specified in SECTION 01 40 00.

1.07 SOURCE QUALITY CONTROL:

A. Tests, inspections: At the shop, factory, plant, or place of manufacture.

B. Verification of performance:
   1. All Equipment and Material designs furnished shall be identical to equipment and material designs having an acceptable history of domestic service for a period of not less than three years at comparable temperature, voltage, and design stress levels.
   2. Equipment and Material designs with less than three years of actual service will be considered from established manufacturers but shall be furnished only if accepted by Engineer and Owner prior to award of Contract.

1.08 DELIVERY, STORAGE, AND HANDLING:

A. As specified in SECTION 01 60 00.

1.09 PROJECT SITE CONDITIONS:

A. Altitude = 5100 feet above mean sea level.

B. Minimum and maximum outdoor ambient temperature range = -20 ºF - 105ºF.

C. Minimum and maximum indoor conditioned temperature range = 50ºF - 85ºF.

D. Maximum Outdoor Relative Humidity = 100%.

E. Seismic Factors : Refer to Structural.

1.10 WARRANTY:

A. The warranty shall comply with the requirements of SECTION 01 78 36.

PART 2 - PRODUCTS

2.01 GENERAL:

A. Furnish and install Materials in accordance with NEC and NFPA 70E.
B. All components and Material shall be new and free of defects using UL recognized components.
C. All electrical Equipment, motors, panels, systems and skids shall be UL listed.
D. Fabricated panels and skids in accordance with NEMA standards.
E. All Equipment conductor termination shall be UL listed for 75°C unless specified otherwise.
F. Identify and label with permanent labels all Equipment and Material used to complete this Work. Labels clearly indicating design intent in accordance with the Contract Drawings and as specified in DIVISION 26.
G. Perform all Work Source Limitations: To the fullest extent possible, provide products of the same kind from a single source.

2.02 SYSTEMS:

A. Furnish, install and make suitable for operation the following systems:
   1. 480 V, 3 phase, 60 hertz, 3 wire power distribution system.
   2. 120/240 V, single phase, 60 hertz, 3 wire lighting, convenience power, and small power system.
   3. Grounding and bonding system.
   4. Underground duct banks, including handholes and manholes.
   5. Fiber Network.

2.03 ELECTRICAL MATERIAL SERVICE REQUIREMENTS:

A. Refer to electrical drawings.

2.04 MOTOR CONTROL CENTER:

A. Submittals:
   1. Product Data: Submit for each type of product specified and included, with the following as minimum:
   2. Data sheets for all components furnished as part of the system package.
B. Manufacturer:
   1. EATON to match existing MCC-WGL-B breakers.
C. Feeder Breakers:
   1. Molded Case Circuit Breakers:
      a. Molded-case, manually-operated, 3 pole.
      b. Trip-free from handle.
      c. Inverse time thermal element overload protection.
      d. Instantaneous magnetic short-circuit protection on all poles.
      e. External handle which clearly indicates when breaker is "ON," "OFF," or "TRIPPED," and lockable in the "OFF" position.
   2. Molded-Case Circuit Breakers With Solid State Trip Unit:
      a. Molded-case, manually-operated, 3 pole circuit breaker with solid state trip unit.
      b. Trip-free from handle.
      c. Solid state trip unit shall have the following features:
         (1) Adjustable long time pickup.

(2) Adjustable long time delay.
(3) Adjustable short time pickup.
(4) Adjustable short time delay.
(5) Adjustable instantaneous time pickup.
(6) Adjustable instantaneous time delay.
(7) Adjustable ground fault time pickup.
(8) Adjustable ground fault time delay.
(9) I^2t settings for instantaneous and ground fault.

d. External handle which clearly indicates when breaker is "ON," "OFF," or "TRIPPED," and lockable in the "OFF" position.

e. Accessories:
(1) Auxiliary contacts as indicated.
(2) Shunt trip.

PART 3 - EXECUTION

3.01 GENERAL

A. Perform all Work in accordance with:
1. NEC and NFPA 70E.
2. NECA National Electrical Installation Standards (NEIS)

B. Perform all Work necessary to furnish, receive, store, install, connect, tube, wire, pipe and commission electrical equipment:
1. In strict accordance with the manufacturer's recommendations.
2. To power and operate the systems and process.
3. As specified and indicated on the motor schedule, equipment schedule, valve schedule, Process and Instrumentation diagrams (P&IDs), and Electrical Drawings.

C. Provide all Material to mount on floor or wall.

D. Concrete work for all electrical equipment pads, foundations, duct banks and other DIVISION 26 applications shall conform to DIVISION 03 – Concrete.
1. Provide concrete mounting pads for equipment located outdoors.
2. Provide housekeeping pads for Equipment located indoors.

E. Install systems, Equipment and Material level, plumb, parallel, and perpendicular to other building systems and components, where installed in finished spaces.

F. Install electrical Equipment and Material to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting with minimum of interference with other installations.

G. Install raceways, cables, wireways, cable trays and busways clear of obstructions and clear of the required working space of equipment.

H. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

I. Provide all equipment, materials, scaffolding, rigging, and tools to complete the Work.

J. Provide all labor, including expert and common, specialized personnel, fitters, electricians, and attendance of such personnel.

K. Electrical Plan Drawings shall be used to determine approximate location of Equipment to be installed and cable lengths. Contractor shall advise the Engineer of interferences.

L. Equipment not indicated on the Electrical Plan Drawings but listed in the Equipment schedule, shall be field located by the Contractor with the assistance of the Engineer.

M. Install permanent equipment labels for all Equipment, Material and devices or as directed by the Engineer.

3.02 COORDINATION AND SCHEDULING:

A. Coordinate all installation activities involving others. Identify restraints caused by others which affect performance of the Work. Resolve such restraints where possible and notify the Engineer when additional action is required to complete the Work.

B. Provide a complete construction sequence document to:
   1. List construction milestones
   2. List electrical decommissioning activities
   3. List electrical commissioning activities
   4. Outline the needs for temporary construction power
   5. Demonstrate that all construction activities will not result in a loss of power or interruption to the system process.

C. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

3.03 PREPARATION:

A. Verify existing Site conditions match the specifications.

B. Verify the Contract Documents are consistent with the existing equipment and material installation. Notify Engineer of discrepancies.
   1. Verify all existing dimensions by field measurements.
   2. Arrange for chases, slots, and openings in other building components during progress of construction to allow for electrical installations.
   3. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components as they are constructed.

C. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building. Coordinate concrete pads, bases, roof curbs, and related items.

D. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

E. Refer to equipment specifications in DIVISIONs 26 through 46 and the equipment submittals for rough-in requirements.

3.04 WORK ON EXISTING EQUIPMENT:

A. Do not remove any equipment from service without obtaining permission from Owner and Engineer.

B. Perform work that requires taking equipment out of service at times designated by Owner to cause minimum interruption in plant operation.

C. Continue work with as many workmen as can be efficiently utilized from the time any equipment is removed from service until equipment is tested and back in service.

D. Connect electrical Equipment to provide same phasing as existing equipment, unless otherwise specified or indicated.

E. Disposal of existing fluorescent lamps shall be by Contractor shipping the lamps to an EPA approved recycler for recycling. All shipping and disposal costs will be paid by Contractor at no additional expense to Owner.

F. Existing pre-1980 fluorescent lamp ballasts and ballasts not marked "no PCBs" (or are not dated with manufacturing date) shall be assumed to contain PCBs. Contractor shall dispose of PCB fluorescent ballasts by shipping the ballasts to an EPA approved PCB incineration facility. All shipping and disposal costs will be paid by Contractor at no additional expense to Owner.

3.05 INSTALLATION:

A. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Should coordination requirements conflict with individual system requirements, Notify the Engineer of any conflicts.

B. Where mounting heights are not specifically detailed, specified, or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.

C. All equipment conductor termination provisions and equipment lugs shall be UL listed for 75ºC.

D. All electrical equipment and installations shall be of adequate strength to withstand, without failure, forces encountered in defined Seismic conditions.

E. Equipment provided by this Contractor motor horsepower, kilowatt or cable sizes is approximate; If the Contractor installs a different size or type, then at no additional cost to the Owner, the Contractor shall provide components, Equipment, and Materials as recommended by the equipment manufacturer or required to stay compliant with the NEC. Including but not limited to:

1. Motor controller.
2. Cables.
3. Cable Lugs.
4. Conduit.
5. Fuses or circuit breakers.

3.06 TESTING:

A. Test all electrical Equipment upon completion of installation to ensure that the Equipment operates satisfactorily to the Owner and conforms to Contract Documents.

B. Furnish temporary power sources of proper type for testing purposes when normal supply is not available at the time of testing.

3.07 DEMOLITION:

A. Protect existing electrical equipment and installations indicated to remain. If damaged or disturbed in the course of the Work, remove damaged portions and install new products of equal capacity, quality, and functionality.

B. Accessible Work: Remove exposed electrical equipment and installations, indicated to be demolished, in their entirety.

C. Abandoned Work: Cut and remove buried raceway and wiring indicated to be abandoned in place, 2 inches below surface of adjacent construction. Cap raceways and patch surface to match existing surface finish.

D. Remove demolished material from Project Site.

E. Remove, store, clean, re-install, reconnect and make operational components indicated for relocation.

3.08 CUTTING AND PATCHING:

A. General: Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of the trades involved. In addition to the requirements specified in DIVISION 01, the following requirements apply:
   1. Perform cutting and patching for electrical equipment and materials required to:
      a. Uncover work to provide for installation of ill-timed work.
      b. Remove and replace defective work.
      c. Remove and replace work not conforming to requirements of the Contract Documents.
      d. Remove samples of installed work as specified for testing.
      e. Install equipment and materials in existing structures.
      f. Upon written instructions from Engineer, uncover and restore work to provide for Engineer's observation of concealed work if installed without using the proper specified procedures.

B. For work in existing installations, the Contractor shall cut, remove, and legally dispose of selected electrical equipment, components, and materials as indicated, including, but not limited to, removal of electrical items indicated to be removed and items made obsolete by the new work.

C. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

D. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

E. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.

F. All penetrations through fire-rated walls, ceilings and floors shall be sealed with a UL listed and FM Global approved sealant system that matches the fire rating of the surface penetrated.

G. Patch existing finished surfaces and building components that must be cut for the electrical installation or are damaged by Contractor using new materials matching existing materials.

3.09 FINISHES:

A. Clean damaged and disturbed areas and apply primer, intermediate, and finish coats to suit degree of damage at each location.

B. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.

C. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

D. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

E. Repair damage to protective coatings in accordance with SECTION 09 90 00 - Protective Coatings.

3.10 CLEANING:

A. On completion of installation, including outlets, fittings, and devices, inspect exposed finish. Remove burrs, dirt, paint spots, and construction debris.

3.11 PROTECTION:

A. Protect equipment and installations and maintain conditions to ensure that coatings, finishes and cabinets are without damage or deterioration at time of Substantial Completion.

3.12 CLOSEOUT:

A. Instructions, training, and manufacturer's service representative:
   1. Provide on-site instructions and training of Owner's personnel as specified.
   2. Provide on-site services of a manufacturer's authorized service representative as specified.

END OF SECTION 26 00 00

SECTION 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLE

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and DIVISION 01 Specification Sections, apply to this SECTION.

1.02 SUMMARY:

A. This SECTION includes the requirements for furnishing and installing (including terminations) all low-voltage electrical conductors, cable, and accessories.

1.03 RELATED REQUIREMENTS:

A. SECTION 26 00 00 - Electrical
B. SECTION 26 05 26 - Grounding and Bonding for Electrical Systems
C. SECTION 26 05 33 - Raceway and Boxes for Electrical Systems
D. SECTION 26 05 43 - Underground Ducts and Raceways for Electrical Systems
E. SECTION 26 05 44 - Sleeves and Sleeve Seals for Electrical Raceways and Cabling
F. SECTION 26 05 53 - Identification for Electrical Systems
G. SECTION 40 66 00 - Process Control Networks.

1.04 REFERENCE STANDARDS:

A. Publication Dates: Comply with standards in effect as of the date of the Contract Documents unless otherwise indicated.
B. ASTM International (ASTM):
    1. ASTM B3 – Standard Specification for Soft or Annealed Copper Wire.
    2. ASTM B8 – Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
    3. ASTM B33 – Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes.
    4. ASTM B172 – Rope-Lay Stranded Copper Conductors Having Bunch-Stranded Members, for Electrical Conductors.
C. Insulated Cable Engineers Association (ICEA):
    1. ANSI/ICEA S-81-570 – 600Volt Rated Cables of Ruggedized Design for Direct Burial Installations as Single Conductors or Assemblies of Single Conductors.
    2. ANSI/ICEA S-105-692 – 600Volt Single Layer Thermoset Insulated Utility Underground Distribution Cables.
    3. ICEA T-29-520 – Vertical Cable Tray Flame Tests at 210,000 Btu.
D. Institute of Electrical and Electronics Engineers (IEEE):
    1. IEEE 1202 – Flame-Propagation Testing of Wire and Cable.
E. International Electrical Testing Association (NETA):
    1. ANSI/NETA ATS – Acceptance Testing Specifications for Electrical Power Equipment and Systems.
F. National Electric Manufacturers Association (NEMA) and Insulated Cable Engineers Association (ICEA):
    1. ANSI/NEMA WC 53/ICEA T-27-581 – Standard Test Methods for Extruded Dielectric Power, Control, Instrumentation, and Portable Cables for Test
    2. NEMA WC57/ ICEA S-73-532 – Standard for Control, Thermocouple Extension, and Instrumentation Cables.
    3. ANSI/NEMA WC 70/ICEA S-95-658 – Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy
G. National Fire Protection Association (NFPA):

1. NFPA 70 – National Electrical Code (NEC).

H. Underwriters Laboratories, Inc. (UL):
1. UL 44 – Thermoset Insulated Wires and Cables.
2. UL 83 – Thermoplastic Insulated Wires and Cables.
3. UL 854 – Service Entrance Cables.
4. UL 1277 – Standard for Electrical Power and Control Tray Cables with Optional Optical Fiber Members.
5. UL 1581 – Reference Standard for Electrical Wires, Cables, and Flexible Cords
6. UL 1651 – Optical Fiber Cable.
7. UL 1666 – Flame Propagation Height of Electrical and Optical Fiber Cables Installed in Vertical Shafts.
8. UL 1685 - Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables

1.05 SUBMITTALS:

A. In addition to the requirements of SECTION 01 33 00, submittals shall also include, but not be limited to, the following:
1. Product Data: For each type of product submit the following marked for intended location and use:
a. Data sheets for each wire and cable type specified.
b. Data sheets for wire and cable accessories.
c. Cable manufacturer's approval of splicing and terminating materials.
d. Cable manufacturer's approval of pulling compounds.
e. Cable manufacturer's installation requirements such as maximum pulling tensions, sidewall pressures, minimum bending radii, and other considerations.
f. Other Equipment and Materials to be used.
2. Special Procedure Submittals:
a. Test Plan:
(1) Provide a complete and detailed test plan for the fiber optic and network cabling system including a complete list of test equipment.
b. Include procedures for certification, validation, and testing.

1.06 DELIVERY, STORAGE, AND HANDLING:

A. As specified in SECTION 01 60 00.

1.07 QUALITY ASSURANCE:

A. As specified in SECTION 01 40 00.
B. Factory Tests:
1. Quality Control Test Protocol: The manufacturer shall conduct tests according to industry standard requirements. These tests shall be performed routinely on sample sizes sufficient to verify quality and continuity or as specified.
2. The end-to-end attenuation of each reel of fiber optic cable supplied shall be tested. All of the fibers per reel shall be tested. The results shall be recorded and provided with the cable when shipped. A copy of these test reports shall be submitted to Contractor.
C. Fiber Optic Cable Site Tests:
1. Upon delivery of the fiber optic cable to the specified location, the Contractor shall perform acceptance testing.

2. Perform optical fiber end to end attenuation tests using an optical light meter and manufacturer's recommended test procedures.
3. Perform tests in accordance with TIA-526-14-B, Method B for horizontal, multimode optical fiber.
4. Copies of the tests showing the attenuation results for each fiber shall be submitted to the Contractor no later than 5 days after acceptance of the cable.
5. Any visible damage to the cable construction should be brought to the Contractor's attention immediately.
6. Refer to PART 3 – EXECUTION for additional site testing requirements.

D. Installer Qualifications:
1. Prior to installation, submit data of installer's experience and qualifications.
2. Network equipment installers shall be a Building Industry Consulting Service International (BICSI) Registered Cabling Installation Technician or have experience which shall include 3 years on projects of similar complexity.
3. Include manufacturer training certification for fiber optic connectors.
4. Include names and locations of two projects successfully completed using managed Ethernet switches, optical fiber and copper communications cabling systems.
5. Include written certification from users that systems have performed satisfactorily for not less than 18 months.
6. Include specific experience in installing and testing structured communications distribution systems using managed Ethernet switches, optical fiber, and Category 6 cabling systems.

1.08 WARRANTY:

A. The warranty shall comply with the requirements of SECTION 01 78 36.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

A. Cable Connectors for Control and Instrument Cable:
1. TE Connectivity Ltd.
2. Hollingsworth Solderless Terminal Company.
3. Panduit Corporation.
4. 3M Company.
5. Thomas and Betts Company, Inc.

B. Cable Connectors for Power Cable:
1. TE Connectivity Ltd.
2. Thomas and Betts Company, Inc.
3. 3M Company.
4. Panduit Corporation.

C. Termination and Splice Kits:
1. 3M Company.
2. Raychem.

D. Shielded VFD Power Cable Termination Kits:
1. Service Wire Company.
2. Southwire Company LLC.

E. Tape and Insulation Putty:
1. 3M Company.

F. Cable Ties:
   1. TE Connectivity Ltd.
   2. Avery-Dennison Corporation.
   3. Panduit Corporation.
   4. 3M Company.
   5. Thomas and Betts Company, Inc.

G. Cable Supports:
   1. Emerson - O. Z./ Gedney Company.
   2. Hubbell, Kellems Grips.

H. Terminal Blocks:
   1. Allen Bradley.
   2. Buchanan.
   3. Phoenix Contact.
   4. Square D Company.
   5. Weidmuller.

I. Cable Identification Tags:
   1. Allen Marking Products.
   2. Panduit.
   3. Specialty Products Company.
   4. Thomas and Betts.
   5. Brady Corporation.

J. Fiber-Optic Cables:
   1. AFL.
   2. Avaya Inc.
   3. Belden Inc.
   4. Berk-Tek, Nexans.
   5. Draka Cableteq USA Corporation, Prysmian Group.
   6. Corning Optical Communications.
   7. CommScope Inc.
   8. General Cable Technologies Corporation.
   9. Mohawk, Belden Inc.
   10. Optical Cable Corporation.
   11. Superior Essex Inc.

K. Fiber-Optic Cable Connectors, Duplex Jumpers, Patch Panels and Accessories:
   1. AFL.
   2. Avaya Inc.
   3. Black Box Corporation
   4. Corning Optical Communications.
   5. Optical Cable Corporation.
   6. Ortronics, Legrand.
   7. Panduit.

2.02 WIRE AND CABLE:

A. General:
   1. All cables surface printing on the cable shall show manufacturer's name, cable type and size, number of conductors, insulation type, and Underwriters Laboratories (UL) Listed.
   2. All cable shall be tested and certified to be in conformance with UL1581 and UL 1685 for the following:

a. Flame exposure
b. Riser cable
c. Crush
d. Impact
e. Flex
f. Pull

3. For location and area classification refer to SECTION 26 00 00, Electrical Material Service Requirements.
   a. For cables routed only through dry environments, cable insulation shall be:
      (1) Polyvinyl chloride "PVC" and rated as Type THHN/THWN.
      (2) Nylon outer jacket outdoor rated Sunlight Resistant, and Oil Resistant.
      (3) THHN/THWN tested and certified to be in conformance with UL 83.
   b. For cables routed through a dry, wet or corrosive environments, cable insulation shall be:
      (1) Cross-linked polyethylene "XLPE" and rated as Type XHHW-2.
      (2) XHHW-2 tested and certified to be in conformance with UL 44.
   c. For cables routed through cable tray cable insulation shall be TC tested and certified to be in conformance with UL 1277.
   d. All cables shall be suitable for operation under the following maximum conductor temperatures:
      (1) 90°C --- Continuous, dry locations
      (2) 75°C --- Continuous, wet locations
   e. For corrosive environments all conductors and terminations should be tin coated.
   f. For cables that enter into a hazardous location the cables shall meet or exceed the hazardous area location rating.
4. All thermocouple extension cables shall be tested and certified to be in conformance with ANSI/NEMA WC 57.

B. Communication Cables: As specified in the Cable Schedule.
   1. Tested and certified to be in conformance with UL 444, UL 1666, UL 1685 and ANSI/TIA-568-C.2.
   2. Suitable for transmitting 1000BASE-TX Gigabit Ethernet, 100BASE-T Fast Ethernet.
   3. Provide industrial ethernet cables as specified for the areas indicated below:
      a. For plant process areas and electrical rooms (Category 6 SF/UTP):
         (1) 300 V RMS.
         (2) Overall foil shield plus tinned copper braid shield.
         (3) Solid bare 26 AWG stranded copper conductors.
         (4) Bonded pairs.
         (5) Polyethylene insulation.
         (6) Riser type CMR/CMX outdoor rated (non-plenum).
         (7) Black UV resistant PVC jacket, with rip cord.

C. Control Cables: As specified in the Cable Schedule.
   1. All Control and Instrument cables shall be tested and certified to be in conformance with ANSI/NEMA WC 53.
   2. 600 V RMS.
   3. Conductor Size #14 AWG
   4. Provide cables with shields based on application:
      a. Unshielded for 120 VAC control signals.

b. Shielded for 24 VDC control signals. Aluminized mylar or polyester tape and tinned copper drain wire.

5. Single conductor cable:
   a. Class B stranded annealed copper.
6. Multi conductor cable:
   a. Type TC
   b. Class B or C stranded annealed copper.
   c. Color coding shall be Method 1 (NEMA WC57/ICEA S 73-532 Appendix E, Paragraph. E3.1) using color pigmented compounds with colors as designated by Table E-2 (K-2).
   d. Polyvinyl chloride "PVC" outer jacket and rated for outdoor use.

D. Fiber Optic Cables: as specified in the cable schedule
   1. Provide fiber with number of strands as indicated on the cable schedule.
   2. All cable supplied shall meet the flame test requirements of UL 1666 and the crush, impact, and flex resistance test requirements of TIA-455-41 and flex resistance testing TIA-455-104.
   3. ICEA-S-83-596, ICEA-S-104-696, ANSI/TIA-568.3-D, UL Listed Type OFNR (UL 1666) and FT4, NEC SECTION 770.179(b) OFNR for use in vertical runs in building riser shafts from floor to floor.
   4. Provide overall armored fiber for exposed or trenched fiber which may be accessible to rodents.
   5. Provide Fiber type based on the length of run:
      a. Less than one mile: Multimode
         (1) Distribution class grade.
         (2) 900 micrometer Tight Buffered low smoke PVC.
         (3) Acrylate Fiber Coating. Water Blocking Aramid Yarn Strength Members.
         (4) Flame retardant PVC for riser applications.
         (5) Indoor/Outdoor water and fungus resistant PVC outer jacket with rip cord.
         (6) OM3 ISO/IEC 11801 with Core Cladding Diameter 62.5 micrometer, color coding according to TIA-598-C. 10 Gb/s.
         (7) Max attenuation 4.1 db/km @ 850 / 1.2 db/km @ 1300nm
      b. Greater than one mile: Single mode Fiber
         (1) Distribution class grade.
         (2) Loose Buffered
         (3) Outdoor harsh environment rated for direct burial and wet environments.
         (4) Medium density polyethylene jacket.
         (5) Indoor/Outdoor water and fungus resistant PVC outer jacket with rip cord.
         (6) OS2 ISO/IEC 24702 with Core Cladding Diameter 125 micrometer, color coding according to TIA-598-C.
         (7) Max attenuation 0.4 db/km @ 1310 / 0.3 db/km @ 1550nm.

E. Ground Conductors: Applies to all cables as specified in SECTION 26 05 26 - Grounding and Bonding for Electrical Systems and as indicated on the electrical Grounding Drawings.
   1. Annealed, bare copper
      a. Uncoated for general service
      b. Tin-coated for corrosive environments
   2. Solid in sizes 4 AWG and smaller. (ASTM B3)
   3. Class B stranded in sizes 2 AWG and larger (ASTM B8)

F. Instrument Cables: As specified in the Cable Schedule

1. All Control and Instrument cables shall be tested and certified to be in conformance with ANSI/NEMA WC 53.
2. 600 V RMS.
3. Conductor Size #16 AWG
4. Class B or C stranded annealed copper.
5. Color coding shall be Method 1 (NEMA WC57/ICEA S 73-532 Appendix E, Paragraph. E3.1) using color pigmented compounds with colors as designated by Table E-2 (K-2).
6. Polyvinyl chloride "PVC" and rated for outdoor use.

G. Power Cables: Applies to all cables to provide power for Wiring Devices and Lighting fixtures and as specified in the Cables schedule.
1. All Power cables shall be tested and certified to be in conformance with ANSI/NEMA WC 70.
2. Individual conductors or multi-conductor cables shall be identified by means of solid colors, stripes, or printing, and in accordance with NEMS WC 70.
3. Conductor sized as specified in the cable schedule, with a minimum of #12 AWG or larger.
   a. For cables #10 AWG or smaller, cables are to be solid.
   b. For cables #8 or larger, cables are to be stranded.
4. Single conductor cable shall be used as specified in the cable schedule, outdoors and in underground duct bank applications:
   a. Class B stranded annealed copper.
5. Multi conductor cable shall be used indoors:
   a. Class B or C stranded annealed copper.
   b. Polyvinyl chloride "PVC" outer jacket and rated for outdoor use.
6. Metal clad:
   a. Type MC
      (1) Class B or C stranded annealed copper
      (2) Class B stranded insulated copper ground conductor sized in accordance with Table 5-2 NEMA WC70/ICEA S-95-658
      (3) Conductors cabled together, binder tape bearing the print legend wrapped around the assembly, and an aluminum interlocked armor applied over the assembly.

H. VFD Cables: As specified in the Cable Schedule.
1. As specified in the Cable Schedule, or approved equal.
2. All Power and VFD cables shall be tested and certified to be in conformance with ANSI/NEMA WC 70.
3. Individual conductors or multi-conductor cables shall be identified by means of solid colors, stripes, or printing, and in accordance with NEMS WC 70.
4. Three symmetrical Class B stranded bare copper ground conductors sized in accordance with Table 5-2 NEMA WC70/ICEA S-95-658.
5. Copper tape shields with 100% coverage.
6. Polyvinyl chloride "PVC" oil resistant jacket, rated for outdoor use.

2.03 CONNECTORS:

A. General Requirements:
1. Designed and sized for specific cable being connected.
2. Solderless, pressure type connectors constructed of non-corrodible tin plated copper.

3. Application tooling for connectors shall contain die or piston stops to prevent over crimping and cycling or pressure relief to prevent under crimping. Dies of all application tooling shall provide dot or wire size coding for quality control verification. All tooling shall be manufactured by the connector manufacturer.

B. Power Connectors (10 AWG and Smaller) 600V and Below:
1. "Scotchlok" pre-insulated spring wire connectors.
2. Buchanan open end copper splicing caps, applied with "Lok Seal" tool, with nylon snap on insulators.

C. Power Connectors (sizes 8 to 4 AWG) 600V and Below:
1. Non-insulated ring tongue type.
2. Ring tongue sized to match terminal stud size.
3. Brazed barrel seam.
4. Application tooling designed to crimp the wire barrel (conductor grip) with a one-step crimp.

D. Power Connectors (sizes 2 AWG to 750 KCMIL) 600V and Below:
1. Non-insulated one hole rectangular tongue for sizes 2 AWG through 3/0 AWG and two hole rectangular tongue for 4/0 AWG through 750 KCMIL.
2. Acceptable manufacturers' cross reference chart is listed at end of this SECTION.

E. Power Connectors (sizes 2 AWG to 750 KCMIL) above 600V:
1. Non-insulated one hole rectangular tongue for sizes 2 AWG through 3/0 AWG and two hole rectangular tongue for 4/0 AWG through 750 KCMIL.
2. Voltage rating equal or greater than that of the cable being used.
3. Application tooling shall be hydraulically operated.

F. Control, Instrument, and Specialty Cable Connectors:
1. Tin plated copper.
2. Vinyl or nylon pre-insulated ring tongue type. Spade lugs will not be permitted.
3. Vinyl pre-insulated spring type spade terminals. (Hollingsworth "Mini Spring Spades"; Thomas and Betts "Locking Fork"; Panduit "Locking Fork.")
4. Sized to match terminal stud size.
5. Have insulation grip sleeve to firmly hold to cable insulation.
6. Insulation grip sleeve shall be funneled to facilitate wire insertion and prevent turned back strands.
7. Application tooling designed to crimp the wire barrel (conductor grip) and the insulation grip sleeve with a one-step crimp.

2.04 MOTOR LEAD TERMINATION/SPLICE (LOW VOLTAGE, 600 V AND BELOW, POWER CABLE):

A. Splices shall be made using compression type connectors bolted together. The compression type connectors shall be properly sized for the cables. Reference acceptable connector manufacturer's cross reference chart.

B. Splice to be covered with heat shrinkable tubing connector insulators or slip-on rubber boot or sleeve.

C. Splicing shall be done in accordance with the instructions provided with the Raychem brand MCK Motor Connector Kit or 3M Company 5300 Series Motor Lead Splice Kit.

2.05 VFD CABLE TERMINATION KITS:

A. Provide termination kit designed for terminating VFD cable shield.

B. Flat tinned copper braid with woven tinned copper construction conforming to ASTM B-33, constant force spring clamp, and adhesive-backed copper foil tape for EMI/RFI shielding conforming to UL 510 for flame retardancy.
C. Conform to requirements of ASTM B-33 and UL 510.
D. Termination kit shall be designed for use with VFD cable and approved by the cable manufacturer.

2.06 CABLE TIES:

A. Nylon self-locking type.
B. Have a normal service temperature range of 40°C to 85°C.
C. Be weather resistant type for outdoor use.
D. TE Connectivity "AMP TY," Avery-Dennison "BAR LOK," Panduit Corporation "PAN TY," Thomas & Betts "TY RAP," or 3M Brand cable ties.

2.07 TERMINAL BLOCKS:

A. For mounting in terminal boxes (TBs):
   1. Designed and sized for the cables being terminated.
   2. Block rated 600V.
   3. Binding screw type terminals for power cables and strap screw or tubular clamp terminals for control and instrument cables.
   4. Rated current carrying capacity equal to or greater than the cable being terminated.
   5. Marking strip.
B. For Mounting in Cabinets, Panels, Control Boards, etc.:
   1. Designed and sized for the cables being terminated.
   2. Block rated 600V.
   3. Binding screw type terminals for power cables and current transformer circuits and strap screw or tubular clamp terminals for control and instrument cables.
   4. Rated current carrying capacity equal to or greater than the cable being terminated.
   5. Marking strip on blocks for power cables and control and instrument cables.
   6. Short circuit strips with one shorting screw for each terminal for current transformer circuits.
   7. Shorting type terminal blocks rated for 10 AWG shall be used for all cables connected to current transformers (CTs).

2.08 CABLE IDENTIFICATION TAGS:

A. Provide cable tags identification as specified in SECTION 26 05 53.

2.09 FIBER-OPTIC PATCH PANELS:

A. Shall be a complete system of components by a single manufacturer, and shall provide termination, splice storage, routing, radius limiting, cable fastening, storage, and cross connection.
B. Shall be capable of terminating number of fibers indicated.
C. Shall be equipped with strain-relief and routing guides for incoming cables to ensure minimum bend radius is not exceeded.
D. Patch panels shall be provided with adapter plates loaded with LC connectors that utilize zirconia ceramic alignment sleeves. Connectors shall be provided with dust covers.
E. Epoxyless crimp style LC connectors compatible with the fiber and shall have maximum attenuation of not more than 0.5 dB.

F. Shall be provided with labeling space, panel directory and warning labels.
G. Panel Mounted:
   1. Single compartment enclosure with fiber optic adaptors mounted in the side of unit.
   2. Shall be mounted in NEMA 4X enclosure or control panels as indicted.
   3. Coordinate size of patch panel with control panel manufacturer.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. General Requirements:
   1. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
   2. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
   3. Install in conduit, tray, duct system, or direct burial as indicated.
   4. Cable shall not be subjected to pulling tensions or sidewall pressures in excess of the manufacturer's recommendations.
   5. Attach pulling grips over the cable sheath to prevent slipping of the insulation.
   6. Do not subject cable to bending radius less than those recommended by the cable manufacturer or as noted below (whichever is greater) during or after installation:
      a. Eight times the cable outside diameter for 600V or lower rated cables.
   7. Install intermediate pull boxes as indicated or as required to avoid subjecting cable to excessive pulling tension or sidewall pressures.
   8. Support cables at connections or termination points such that any strain on cable will not be transmitted to the connection or termination.
   9. Install cable supports in vertical runs of tray or conduit, at boxes and at terminations in equipment, and as required to meet intermediate support requirements of National Electrical Code (NEC).
   10. All pulling compounds shall be approved by wire and cable manufacturer as being compatible with cable materials.
   11. Attach a cable identification tag to each cable at all termination or end points.
   12. Install fire and smoke stop fittings at all cable penetrations of fire rated walls, floors, and ceilings.
   13. Install conduit seals for conduits that terminate in a junction box located in an area identified as Hazardous (Classified) Location on the Contract Drawings.

B. Power (600V and Below), Control, Instrument, and Specialty Cable:
   1. Install metallic barrier in all tray and boxes to separate power, control, and instrumentation from low level signal (50V or less) instrumentation circuits where run in the same tray or box.
   2. Secure with cable ties in cable tray risers at intervals not to exceed 3 feet.
   3. Tie together with cable ties all single conductor cable on each individual circuit in each junction box, equipment or manhole, and in cable tray, at intervals not to exceed 6 feet.
   4. Attach a cable identification tag to each cable.
      a. At each terminal to identify the circuit and cable.
      b. Attach fiber tags with cable ties.
      c. Use nylon ties and identification tabs color coded as follows:
         (1) 480V circuits – Red.
         (2) 277, 240, or 208Vac circuits – Orange.
         (3) 120V circuits – White.

(4) Control cables – Natural Nylon.

5. Insulation Color Coding for Phase Identification:
   a. Color code 600-volt insulated, service entrance, feeder, and branch circuit conductors with factory-applied colored insulation for No. 8 AWG and smaller (except: No. 6 AWG and smaller for green ground wire); 1-inch band of colored tape at all splices and terminations for No. 6 AWG and larger (except: No. 4 AWG and larger for green ground wire) as follows:

Phase	208Y/120 Volts	480Y/277 Volts
A	Black	Brown
B	Red	Orange
C	Blue	Yellow
Neutral	White	Gray
Ground	Green	Green

   b. Tag each individual conductor or wire with wire markers as follows:
      (1) With terminal designation indicated on schematic diagrams or given on manufacturer's equipment drawings.
      (2) At each terminal.
      (3) In addition to specified circuit tags.
   c. Terminate and ground, control, instrument, and specialty cable shields as indicated and recommended by the manufacturer of the equipment being connected. In general, ground the shields at the control panels.
   d. Terminate shields for VFD cables at both the source and load using VFD cable termination kit.
   e. Intermediate cable splices shall not be allowed when installing power, control, and instrument wiring except when spicing to lead wires provided with the equipment or device, or unless approved by the Engineer prior to cable installation.
   f. Control and instrument and thermocouple cable splices shall be as follows:
      (1) Made only in junction or terminal boxes.
      (2) Made on terminal blocks with marking strips.
      (3) Conductor color coding shall be maintained.
      (4) For shielded cables, shield continuity and isolation shall be maintained.
      (5) Thermocouple cable splices to be made only on terminal blocks which correspond to thermocouple type used.
   g. Power cable (600V or below) splices and motor terminations shall be as follows:
      (1) Made only in junction or terminal boxes.
      (2) Splices shall be made using compression type connectors bolted together.
      (3) Splice to be covered with a heat shrinkable connector insulator.
   h. High-Temperature Wiring:
      (1) Install from device to a terminal box for all devices which by their location have the body of the device or electrical connection subject to ambient temperatures in excess of 185°F. Typical locations are feed water heaters, burner fronts, boiler penthouse, and deaerator.
      (2) Locate terminal box far enough from the source of heat so that the temperature does not exceed 175°F. This distance generally is between 3 and 5 feet.

(3) Replace with high-temperature wire any wiring installed by this Contract that is damaged by excessive heat.

6. Ground Cable: Install as specified in DIVISION 26.
7. Control and Instrument Cable: Install as specified in this SECTION.
8. Communications Cable: Install as specified in this SECTION.

C. Direct buried cables:
1. Excavation and backfilling shall be as specified in DIVISION 31.
2. Installation:
a. Install in trenches at least 24 inches below finished grade, except at railroad crossings and under roads or other paved areas exceeding 5 feet in width.
b. Where direct burial cable crosses under railroad tracks, roads, or other paving exceeding 5 feet in width, install cable in concrete encased Schedule 40 PVC conduit. If railroad tracks or paving are in place when the cable is to be installed, a wrought iron pipe driven under the tracks or paving may be used in lieu of the nonmetallic conduit. Extend conduit or pipe at least 5 feet beyond each side of railroad tracks and at least 1 foot beyond the edge of paving.
c. The bottom of the trench shall be smooth and free of stones and sharp objects. Where bottom of trench comprises material other than sand or earth, place a 3 inch layer of sand- or stone free earth on the bottom of the trench and compact to the approximate density of the surrounding firm soil.
d. Unreel the cables in place along the side of or in the trench and carefully place on the sand or earth bottom. Prereeling cables into the trench from a fixed reel position will not be permitted, except as required to pull the cables through conduits under railroad tracks or paving.
e. Where cables cross, provide a separation of at least 3 inches, unless the cables are protected by nonmetallic sleeves at the crossing.
f. The radius of bends in cables shall be not less than 10 times the diameter of the cable. In no case shall cables be left under longitudinal tension.
g. The first layer of backfill shall be of sand- or stone free earth.
h. Place a 1 inch treated plank, not less than 8 inches wide, or approved equal protection, approximately 3 inches above the cable.
i. Place a 6 inch wide yellow Mylar marking tape approximately 12 inches above the buried cable. The tape shall have the following wording printed at intervals along the tape: "Caution Electrical Lines Buried Below." Tape shall be as manufactured by Allen Marking Products.
j. Where cuts are made in paving, restore the paving and subbase to original condition.
k. Center direct burial cable in an entrance to a conduit or duct line. An approved waterproof non-hardening mastic compound shall be used to facilitate the centering.
3. Locate cable markers and splice markers:
a. Locate as indicated.
b. Place approximately 2 feet to the right of the cable or splice when facing the longitudinal axis of the cable and in the direction of the electrical load.
c. The marker shall be Class B concrete, 6 inch square or round section by 3 feet long. The top edge of the marker shall have a 1/2 inch chamfer all around. The letter "C" with two arrows shall be impressed or cast on top of the marker. One arrow shall be located below the letter and shall point toward the cable or splice. When pointing toward a splice, the circle shall be impressed in the shaft of the arrow. The

second arrow shall be located adjacent to the letter and shall point in a direction parallel to the cable. The letter and arrow adjacent to it shall each be approximately 3 inches long. The arrow under the letter shall be approximately 2 inches long. The letter and arrows shall be V shaped and shall have a width of stroke at least 1/4 inch at the top and depth of 1/4 inch.

d. Where the cable changes direction, the arrow located adjacent to the letter shall be cast or impressed with an angle in the arrow approximately the same as the angular change of the cable run. The top of the marker shall protrude not more than 2 inches above finished grade.

D. Cable Connections and Terminations:
   1. Make up clean and tight to assure a low-resistance joint.
   2. Make only in terminal boxes, equipment or other accepted enclosures and not in conduit or cable tray.
   3. Install all connectors with tooling manufactured by the connector manufacturer and as specified.

E. Fiber Optic Cable:
   1. Contractor shall exercise due caution during installation of the fiber-optic cable to prevent damage to glass fibers. Follow manufacturer's recommendations for maximum cable lengths.
   2. Fiber optic cable shall not be spliced, pull continuous run of cables from patch panel to patch panel as specified in the cable schedule.
   3. Install cables in conduit and underground duct bank as indicated and specified.
   4. All pull boxes and termination cabinets shall be clearly identified as containing fiber-optic cable.
   5. Install pull boxes as required and patch panels at the end of each fiber cable.
   6. Terminate each strand of fiber on a patch panel to complete and protect the Work. No strands should be left unterminated.
   7. Cable Bends:
      a. Make gradual bends of cable, where necessary.
      b. Do not allow cable to be sharply bent or kinked at any time.
      c. Maximum bending radius per the cable manufacturer.
      d. Verify that after installation the cable tie support do not places excessive strain on fiber or over time cause the fiber to exceed its bend radius.
   8. Cable Pulling:
      a. Do not exceed manufacturer's recommended pulling tension.
      b. Tension shall be monitored at all times with a dynamometer or with a pulling wheel.
   9. Cable identification tags shall be installed at each pull box.
   10. Label cable at each termination points with unique number for each cable segment.
   11. Cable Ties: Dress cables neatly with cable ties using low to moderate pressure.
   12. Testing Cables: Testing shall be performed in accordance with TIA-568-C.0.
      a. Clean all connections and adapters at each optical test point prior to taking measurements, as per TIA-526-14-B.
      b. The recommended test method shall be TIA-526-14B method B.
   13. Cable Slack:
      a. Leave extra slack on cables, neatly coiled-up in patch panel box.
      b. Leave a minimum of 10 feet of cable slack at each manhole and fiber patch panel.
   14. Do not install cables taut.

F. Fiber Optic Patch Panels:
   1. Install rack mounted patch panels in equipment racks and as indicated.
   2. Install panel mounted enclosures in NEMA rated enclosure or control panels as specified and indicated. For panels installed in equipment manufacturer's control panels coordinate with supplier for required panel space and location.
   3. Arrange with proper clearances from other equipment and material to obtain accessibility for operation and maintenance.
   4. Install adaptor plates and connectors in accordance with manufacturer's recommendations.
   5. Utilize panel spools for slack management of individual fibers.
   6. Mount plumb and level.
   7. Complete panel directory and labeling.

3.02 FIELD QUALITY CONTROL:

A. Perform tests and inspections and prepare test reports. Submit test reports as specified.

B. General Requirements:
   1. Test all wire, cable, and electrical equipment installed or connected by Contractor to assure proper installation, setting, connection, and functioning as indicated or to conform to Contract Documents and manufacturer's instructions.
   2. Conduct all tests except megger insulation testing in the presence of Engineer and/or Owner and under the supervision of Equipment manufacturer's field engineer.
   3. Include all tests recommended by the Equipment manufacturer unless specifically waived by Engineer.
   4. Include all additional tests issued by Engineer that he deems necessary because of field conditions to determine that Equipment and Material and systems meet requirements of Contract Documents.
   5. Include all tests recommended by the NETA Acceptance Testing Specifications.
   6. The contractor shall be responsible for all damage to Equipment or Material due to improper test procedures or test apparatus handling.

C. Cable Testing Requirements:
   1. Megger all 600V insulated power cable with a 1000Vdc megger for one minute, and values must not be less than 50 megohms per NETA ATS 7.3. Determine the values with all switchboards, panelboards, fuse holders, switches, and overcurrent devices in place. Do not connect motors and transformers during meggering. Megger wire and cable after installation and not on the cable reel.
   2. Cables with conductors failing this test shall be removed and replaced.
   3. Provide all phasing tests and make all changes necessary to assure proper rotation of all motors, the correct phasing and phase sequence of all circuits susceptible to being paralleled, the proper polarity on all instrument transformer wiring, and such other phasing tests as may be required for the equipment being connected under this Contract.

D. 600V Control Cable:
   1. Check all control cable for rightness of terminal contacts.
   2. Megger the specific control cables selected by Engineer. The quantity of cables required to be meggered will not exceed 10% of the control cable installed by this Contract. Megger as described for 600V power cable after installation, but with cables disconnected from control panels and other equipment.
   3. All control cables shall have a continuity check performed on each conductor to ensure the conductance of each wire before the wires are terminated.

4. Cables with conductors failing this test shall be removed and replaced.

E. 300V Instrument Cable:
   1. Megger the specific instrument cables selected by Engineer. The quantity of cables required to be meggered will not exceed 10% of the instrument cable installed by this Contract. Insulation resistance shall be a minimum of 1,000 megohms per 1,000 feet.
   2. All instrument cables shall have a continuity check performed on each conductor and shield to ensure the conductance of each wire and shield before the wires are terminated.
   3. Cables with conductors or shields failing this test shall be removed and replaced.

F. Quality Assurance:
   1. Test Reports:
      a. Submit as specified in DIVISION 01.
      b. Maintain a written record of all tests showing date, personnel making tests, equipment used, Equipment or Material tested, tests performed, and results.
      c. Notify Engineer two weeks prior to commencement of all testing except for megger tests.

END OF SECTION 26 05 19

SECTION 26 05 26 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and DIVISION 01 Specification Sections, apply to this SECTION.

1.02 SUMMARY:

A. This SECTION specifies electrical grounding and bonding Work by this Contract.
B. Provide a grounding system as indicated on Drawings and schedules and as specified herein.
C. Bond each conduit and electrical equipment enclosure with the source to create a low impedance ground-fault current path facilitating operation of the overcurrent protection devices.
D. Type of electrical grounding and bonding Work specified in this Section includes solidly grounded systems.
E. Applications of electrical grounding and bonding Work in this SECTION includes the following:
   1. Underground metal piping.
   2. Underground metal water piping.
   3. Metal building frames.
   4. Electrical power systems.
   5. Separately derived systems.
   6. Raceways.
   7. Boxes and enclosures.
   8. Equipment.

1.03 RELATED REQUIREMENTS:

A. SECTION 26 00 00 - Electrical
B. SECTION 26 05 19 - Low-Voltage Conductors and Cables
C. SECTION 26 05 33 - Raceway and Boxes for Electrical Systems
D. SECTION 26 05 53 - Identification for Electrical Systems
E. SECTION 26 22 13 - Low Voltage Distribution Transformers
F. SECTION 26 24 16 - Panelboards
G. DIVISION 31 - Earthwork:
H. SECTION 40 60 00 - Process Control and Enterprise Management Systems
I. SECTION 40 66 00 - Process Control Networks
J. SECTION 40 67 00 - Control System Equipment Panels
K. SECTION 40 70 00 - Instrumentation For Process Systems
L. SECTION 46 05 13 - Common Motor Requirements for Water and Wastewater Equipment.

1.04 REFERENCE STANDARDS:

A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.
B. ASTM International (ASTM):
   1. ASTM B3 - Soft or Annealed Copper Wire.
   2. ASTM B8 - Concentric Lay Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
   3. ASTM B33 - Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes.
C. Institute of Electrical and Electronic Engineers (IEEE):
   1. IEEE 80 - Guide for Safety in Substation Grounding.

2. IEEE 81 - Guide for Measuring Ground Resistance, and Potential Gradient in the Earth.
3. IEEE 3003.1 - Recommended Practice for the System Grounding of Industrial and Commercial Power Systems.
4. IEEE 3003.2 - Recommended Practice for Equipment Grounding and Bonding in Industrial and Commercial Power Systems.

D. National Electrical Contractors Association (NECA) Installation Standards.
E. National Fire Protection Association (NFPA):
1. NFPA 70 - National Electrical Code (NEC)
F. Underwriters Laboratories (UL):
1. UL 467 - Standard for Safety Grounding and Bonding Equipment.
2. UL 486A - Wire Connectors and Soldering Lugs for Use with Copper Conductors.
3. UL 869 - Electrical Service Equipment.
4. UL 891 - Switchboards.

1.05 SUBMITTALS:
A. Product Data: Submit manufacturer's data on all grounding and bonding components and associated accessories.
B. Qualification Data: For Qualified Testing Agency and testing agency's field Supervisor.
C. All field test reports.

1.06 QUALITY ASSURANCE:
A. Testing Agency Qualifications: Must be a member company of NETA or an NRTL.
1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:
A. Subject to compliance with requirements, provide grounding and bonding products of one of the following (for each type of product):
1. Grounding Products:
a. Anderson Electrical Products, Hubbell Inc.
b. Burndy LLC.
c. Cadweld, Erico, nVent Electric, plc.
d. Crouse-Hinds, Eaton.
e. Erico, nVent Electric, plc.
f. Copperweld Bimetallics, LLC.
g. Myers, Crouse-Hinds, Eaton.
h. O-Z/Gedney, Emerson Electric Company.
i. Thomas & Betts, ABB Group.
j. Engineer-approved equal.

2.02 GROUNDING AND BONDING:
A. Materials and Components:
1. General: Except as otherwise indicated, provide electrical grounding and bonding systems indicated; with assembly of materials, including, but not limited to, cables/wires,

connectors, solderless lug terminals, grounding electrodes, bonding jumper braid, surge arresters, and additional accessories needed for a complete installation. Where more than one type component product meets indicated requirements, selection is Contractor's code-compliance option. Where materials or components are not indicated, provide products which comply with NEC, UL, and IEEE requirements, matching existing system, and with established industry standards for those applications.

2. Conductors: as specified in SECTION 26 05 19.
    a. For buried and exposed grounding conductors as specified for Grounding Conductors.
    b. Bonding conductors shall be the same as specified for Power Cables.
    c. Equipment grounding conductors shall be as specified for Power Cables and in the cable schedule.
3. Separately derived systems: Ground each separately derived system as required by the NEC Article 250.
4. Service Surge Protection: Refer to SECTION 26 43 13. Ground according to manufacturer's installation requirements and recommendations.
5. Bonding Plates, Connectors, Terminals, and Clamps: Provide electrical bonding plates, connectors, terminals, lugs, and clamps as recommended by bonding plate, connector, terminal, and clamp manufacturers for indicated applications.
    a. Bolted Connectors for Conductors and Pipes: Copper or copper-alloy, pressure type with at least two silicon bronze or stainless-steel bolts and lock washers.
    b. Irreversible Compression Fittings: Pure wrought copper extrusion clamps and connectors, made to be held in the dies of an installation tool. Connectors must be factory filled with an oxide inhibitor.
    c. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
    d. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals and long-barrel, two-bolt connection to ground bus bar.
6. Electrical Grounding Connection Accessories: Provide electrical insulating tape, heat-shrinkable insulating tubing, welding materials, bonding straps, as recommended by accessories manufacturers for type service required or indicated.
7. Mastic Coatings:
    a. Sonneborn-Sonoshield Mastics (BASF Construction Chemicals LLC).
    b. W.R. Meadows - Sealmastic.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Install electrical grounding and bonding systems as indicated, in accordance with manufacturer's instructions and applicable portions of NEC, NECA's "Standards of Installation," and in accordance with recognized industry practices to ensure that products comply with requirements.

B. A grounding electrode shall be installed at each building or structure as indicated.
    1. Grounding electrodes shall consist of the following:
        a. Ground rod and cable system.
        b. Concrete-encased electrode.
        c. Grounded metal frame of the building or structure.
        d. Metal underground water pipe.
        e. Other systems or structures as indicated.

C. Grounding Conductors:
   1. Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
   2. Install using as few joints as possible. Route along shortest and straightest paths possible unless otherwise indicated or required by Code.
   3. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage. Suitably protect cable against damage during construction.
   4. Replace or suitably repair cable if damaged by anyone before final acceptance.
   5. In Exposed Installations:
      a. Route runs as indicated.
      b. Route along the webs of columns and beams, and in corners where possible for maximum physical protection.
      c. Where physical protection is required, install in PVC conduit unless indicated otherwise.
      d. Support at intervals of 3 feet or less with nonmagnetic clamp-type supports.
   6. In Buried Installations:
      a. Conductor sizes shall be as indicated for specific connections. For required connections not indicated, use conductor size not less than No. 3/0 AWG if buried in the earth or cast in concrete, or No. 6 AWG at other locations.
      b. Lay in bottom of trench or in other excavations at the depth of the top of the ground rod.
      c. Bury at least 30 inches (600 mm) below grade.
      d. Maintain clearance of at least 12 inches from all underground metal piping or structures, except where connections thereto are specifically indicated.
      e. Ground cable shall enter the bottom of electrical gear or panels sitting on a slab through a PVC sleeve.
   7. Backfill as specified in DIVISION 31.
   8. Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.

D. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

E. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96A when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

F. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
   1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
   2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
   3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

G. Conductor Terminations and Connections:
   1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors with silicon bronze or stainless-steel bolts and lock washers.

2. Underground Connections: Provide exothermic welded connections where grounding conductors connect to underground grounding conductors and underground grounding electrodes.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel:
   a. Welded connectors where allowed by the structural steel.
   b. Bolted fittings where structural steel cannot be welded, but can be field drilled.
5. Clean metal contact surfaces of clamp-on connectors to ensure electrical conductivity and circuit integrity.
6. Exothermic terminations:
   a. Conform to manufacturer's instructions.
   b. Chemically degrease and dry completely before welding.
   c. Apply one coat of mastic coating to all exothermic-welded connections to be buried.

H. Grounding for Steel Building Structure:
1. Install a driven ground rod – part of the counterpoise system - at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.
2. Extend a bonding conductor from the counterpoise system to the structural steel and exothermically weld or connect with an irreversible compression fitting to the hold-down bolts securing the structural steel column to the support footing or foundation.
3. Exothermically weld to connect the counterpoise system to the steel building column.
4. Extend a bonding conductor from the counterpoise system to the structural steel as indicated. Drill and tap a preinstalled, grounding plate welded to the structural steel and secure the bonding conductor to the building steel with a service post.

I. Grounding Manholes and Handholes:
1. Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches (100 mm) will extend above finished floor.
2. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG minimum bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall.
3. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches (50 mm) above to 6 inches (150 mm) below concrete.
4. Seal floor opening with waterproof, non-shrink grout.

J. Grounding Connections to Manhole Components:
1. Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor.
2. Make connections with No. 4 AWG minimum stranded, hard-drawn copper bonding conductor.
3. Train conductors level or plumb around corners and fasten to manhole walls.
4. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

K. All grounding system components shall be bonded to form one continuous grounding electrode.

L. Ground all exposed noncurrent carrying metal parts of electrical equipment, metal raceway systems, grounding conductors in raceways and cables, receptacle ground conductors, and metallic plumbing systems.

M. Tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values for connectors and bolts. Where manufacturer's torqueing requirements are not indicated, tighten connections to comply with tightening torque values specified in UL 486A to assure permanent and effective grounding.

N. Apply mastic coating to field connections, buried metallic grounding and bonding products, and places where factory applied protective coatings have been destroyed, which are subjected to corrosive action.

3.02 INSTALLATION - EQUIPMENT GROUNDING:

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Terminate feeder and branch circuit insulated equipment grounding conductors with grounding lug on substation, switchgear, switchboard, motor control center, or panelboard ground bus. When conduit enters from below and is not connected to the enclosure, ground equipment grounding conductor on conduit grounding bushing and then bond to ground bus (or grounded enclosure if there is no ground bus).

C. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
   1. Feeders and branch circuits.
   2. Lighting circuits.
   3. Receptacle circuits.
   4. Single-phase motor and appliance branch circuits.
   5. Three-phase motor and appliance branch circuits.
   6. Flexible raceway and power cords runs.
   7. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
   8. Computer and Rack-Mounted Electronic Equipment circuits.

D. Ground wireway at least once and at 10-foot intervals.

E. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

F. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

G. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a separate grounding system complying with requirements in TIA/ATIS J STD-607-A.
   1. For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
   2. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4- by 4- by 12-inch (6.3- by 100- by 300-mm) grounding bus.
   3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

H. Bond all motors and equipment 100 Hp or larger to the grounding electrode system with a minimum No. 1 AWG bare copper wire.
I. Bond all motors with "identified" equipment grounding conductor. Route in conduit with phase conductors.
J. Enclosure Grounds: Bond all enclosures by direct copper connection to the grounding electrode system.
K. Building Grounding Conductors: Support at intervals not to exceed 3 feet on center or as indicated.

3.03 LABELING:
A. Comply with requirements in Section 26 05 53 - Identification for Electrical Systems for instruction signs. The label or its text shall be green.

3.04 INSPECTION:
A. Do not cover up connections before they are inspected by Engineer.
B. Compression-type connections shall be inspected for embossment of proper die index per manufacturer's instructions.

3.05 FIELD QUALITY CONTROL:
A. Perform tests and inspections.
B. Tests and Inspections:
1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. All compression-type connections shall be inspected for proper die index number.
4. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells. Make tests at ground rods before any conductors are connected.
a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
b. Perform tests by fall-of-potential method according to IEEE 81 for the following:
(1) Testing and commissioning of new grounds, not yet connected to the utility power supply.
(2) Testing complex ground systems that include a metallic loop.
C. Grounding system will be considered defective if it does not pass tests and inspections.
D. Prepare test and inspection reports.
E. Report measured ground resistances that exceed the following values:
1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1,000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1,000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).
5. Substations and Pad-Mounted Equipment: 5 ohms.
6. Handhole Grounds: 10 ohms.
F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.

END OF SECTION 26 05 26

SECTION 26 05 29 – HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY:

A. This Section specifies hangers, supports, anchors, sleeves, and seals for electrical equipment and systems as well as construction requirements for concrete bases as indicated by Drawings and schedules and/or specified in other Division 26 Sections.
B. Types of hangers, supports, anchors, sleeves, and seals specified in this Section include the following:
   1. Clevis hangers.
   2. Riser clamps.
   3. Steel rod coupling.
   4. C-clamps.
   5. I-beam clamps.
   6. One-hole conduit straps.
   7. Two-hole conduit straps.
   8. Hexagonal nuts.
   9. Round threaded steel rods.
   10. Conduit clamps.
   11. U-bolts.
   12. Lead expansion anchors.
   13. Toggle bolts.
   14. Wall, ceiling, roof and floor seals.
   15. Conduit cable supports.
   16. U-channel strut system.

1.03 RELATED REQUIREMENTS:

A. Concrete materials, reinforcement, and placement requirements are specified in DIVISION 03 – Concrete.
B. SECTION 26 00 00 - General Electrical Requirements
C. SECTION 26 05 26 - Grounding and Bonding for Electrical Systems
D. SECTION 26 05 33 - Raceway and Boxes for Electrical Systems

1.04 REFERENCE STANDARDS:

A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.
B. ASTM International (ASTM):
   1. ASTM-A780 - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
   2. ASTM-E814 REV A - Standard Test Method for Fire Tests of Penetration Firestop Systems, pertaining to fire stop components.
C. American Welding Society (AWS):
   1. AWS D1.1/D1.1M - Structural Welding Code - Steel.
D. National Fire Protection Association (NFPA):

1. NFPA-70 - National Electrical Code (NEC).

E. National Electrical Contractors Association (NECA):
   1. NECA 1 – Standard Practice of Good Workmanship In Electrical Construction.

F. Society of Protective Coatings (SSPC):
   1. SSPC-PA 1 - Shop, Field and Maintenance Painting of Steel.

G. Underwriters Laboratories (UL):
   1. Provide electrical devices, components, and fire stops which are UL-listed and labeled.

1.05 PERFORMANCE/DESIGN CRITERIA:

A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.06 SUBMITTALS:

A. Product Data:
   1. Submit manufacture's data on supporting devices including catalog cuts, specifications, and installation instructions, for each type of support, anchor, sleeve, and seal.

B. Shop Drawings:
   1. Submit dimensioned drawings of fabricated products, indicating weights, strength, details of fabrication, and details of materials.

1.07 QUALITY ASSURANCE:

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

B. Comply with NEC.

1.08 COORDINATION:

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

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

A. Anchor Manufacturers: Subject to compliance with requirements, provide anchors of one of the following manufacturers.
   1. Hilti, Inc.
   2. Ideal Industries, Inc.
   3. Joslyn Manufacturing Co., Inc.
   4. Eaton/Cooper; McGraw Edison Co.

5. Unistrut; Atkore International.

B. Channel System Manufacturers: Subject to compliance with requirements, provide channel system of one of the following manufacturers.
   1. Allied Tube & Conduit Corp.
   2. Eaton/Cooper; B-Line Systems, Industries.
   3. Erico International Corp.
   4. Kindorf; Thomas & Betts Corp.
   5. Power-Strut; Power Engineering Co.
   6. Unistrut; Atkore International.

2.02 STEEL SUPPORT SYSTEMS:

A. General: Provide supporting devices which comply with manufacturer's standard materials, design, and construction in accordance with published product information, as required for complete installation, and as herein specified. All supports shall be designed for the support of the maximum number of conduits and their maximum conductor weights for maximum conduit loading. Where more than one type of supporting device meets indicated requirements, selection is Contractor's option. Do not use perforated metal straps for supports.

B. Provide as required to rigidly support all conduit runs, boxes, and equipment.

C. Support conduit within 12 inch of enclosures to which conduits are attached.

D. Do not exceed the manufacturers recommended distance between supports on horizontal or vertical runs.

E. Supports: Supporting devices of types, sizes, and materials indicated, and having the following construction features.
   1. Clevis Conduit Hangers: For supporting conduit; galvanized steel; with 3/8-, 1/2-, 5/8- or 3/4-inch rod, size of clevis and rod as required.
   2. Riser Clamps: For supporting conduit, galvanized steel, with two bolts and nuts.
   3. Steel Rod Couplings: Provide 3/8-, 1/2-, 5/8- or 3/4-inch straight rod couplings, size as required.
   4. C-Beam Clamps: Galvanized steel, 3/8-, 1/2-, 5/8-, or 3/4-inch rod, size as required.
   5. I-Beam Clamps: Galvanized steel, with 3/8, 1/2-, 5/8-, or 3/4-inch rod, size as required; 3/8-inch horizontal "J" hook safety rod that bolts across the flange, flange width as required.
   6. One-Hole Conduit Straps: For supporting conduit; galvanized steel, size as required.
   7. Two-Hole Conduit Straps: For supporting conduit, galvanized steel, size as required.
   8. Hexagonal Nuts, Flat Washers and Lock Washers: For 3/8-, 1/2-, 5/8-, or 3/4-inch rod, size as required; galvanized steel.
   9. Round Threaded Steel Rod: Galvanized steel, 3/8-, 1/2-, 5/8-, or 3/4-inch diameter, size as required. Minimum size is 3/8-inch diameter.
   10. Conduit Clamps: For supporting conduit; galvanized stamped steel, size as required.
   11. U-Bolts: For supporting conduit; galvanized, size as required.

F. Fabricated supports:
   1. from structural steel or manufactured framing members equal to "Unistrut" P-3000 (1-5/8 inch by 1-3/8 inch) series as manufactured by Unistrut Corporation, Kindorf B-995 (1-1/2 inch by 1-1/2 inch) series as manufactured by Thomas and Betts, or Superstrut A-1200 (1-5/8 inch by 1-5/8 inch) series as manufactured by Thomas and Betts.
   2. Minimum 12 gauge.

G. Coated Supports:

1. Channel shall be coated using an electro-deposition process with an epoxy or acrylic coating.
2. Inscribed samples shall exceed 600-hour salt spray when tested in accordance with ASTM B117.
3. Provide conduit clamps and hangers finished with the same process as the support and sized for the specific conduit size.
4. Provide zinc-plated anchors, inserts, bolts, washers, nuts, and support hardware.

H. Hot-Dipped Galvanized Supports:
1. Channel shall be hot-dipped galvanized after all manufacturing operations are complete.
2. Channel shall have a minimum of 2.5 mils or 1.5 ounces of coating per square foot on each side of the steel and conform to ASTM A123 and ASTM A153.
3. Provide conduit clamps and hangers finished with same process as the support and sized for the specific conduit size.
4. Provide stainless-steel rods, anchors, inserts, bolts, washers, nuts with all other support hardware hot-dipped galvanized.

I. Stainless-Steel Supports:
1. Channel Type 304 stainless steel conforming to ASTM A240.
2. Stainless-steel conduit clamps and hangers, sized for the specific conduit diameter.
3. Provide stainless-steel rods, anchors, inserts, bolts, washers, nuts, and support hardware.

J. Anchors: Anchors of types, sizes and materials indicated, with the following construction features.
1. Lead Expansion Anchors: 1/2, 5/8, or 3/4 inch as required.
2. Toggle Bolts: Springhead, 3/16 by 4 inch or larger size as required.

K. Conduit Cable Supports: Cable supports with insulating wedging plug for nonarmored type electrical cables in risers; construct for rigid metal conduit (size as required) number of wires as required, type wire as specified; construct body of malleable-iron casting with hot-dip galvanized finish.

L. U-Channel Strut Systems: Unless indicated otherwise, U-channel strut system for supporting electrical equipment, 12-gauge steel hot-dip galvanized after fabrication for wet and outdoor locations, 12-gauge standard green paint finish for dry and indoor locations, of types and sizes indicated; construct with 9/16-inch diameter holes, 8 inch o.c. on top surface, and with the fittings as required which mate and match with U-channel.

M. Fire and Smoke Stop Compounds: Provide one of the following:
1. 3M Fire Barrier 2000+.
2. Hilti, Inc. FS-ONE MAX.

PART 3 - EXECUTION

3.01 ERECTION, INSTALLATION, APPLICATION:

A. Install hangers, anchors, sleeves, and seals as specified, required, indicated, in accordance with manufacturer's written instructions and with recognized industry practices to insure supporting devices comply with requirements. Comply with requirements of NECA and NFPA 70 for installation of supporting devices.

B. Install hangers, supports, clamps, and attachments to support conduit properly from building structure. Arrange for grouping of parallel runs of horizontal conduits to be supported together on trapeze type hangers where possible. Install supports with spacing indicated and as required by NFPA 70 or as indicated when less than NFPA 70 required spacing.

C. Torque sleeve seal nuts, complying with manufacturer's recommended values. Ensure that sealing grommets expand to form watertight seal.
D. Design trapeze type supports, including fasteners to the structure to carry the following loads:
   1. Outdoor supports shall have the following added to the calculated load:
      a. Ice weighing 57 pounds per cubic foot to a thickness of 0.25 inches over the projected area of the supports and conduit being supported.
      b. Snow weighing 8 pounds per square foot over the projected area of the conduit being supported.
      c. Wind at 25 pounds per square foot acting in a downward direction.
   2. The greater of the following:
      a. The total calculated load multiplied by a factor of 4.
      b. The total calculated load +200 pounds.
E. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
F. Repair damage to painted finishes with paint recommended by manufacturer.
G. Install fire and smoke stop compounds at all penetrations of fire rated walls, floors, ceilings and roofs. Install fire and smoke stop compounds in accordance with manufacturer's instructions to provide a fire seal rating equal to or greater than that of the surface penetrated.
   1. Testing shall be performed in accordance with ASTM-E814 REV A and applicable local codes.
H. Provide seismic support and bracing for all multiple conduit support trapezes plus individually supported conduit 2-1/2 inches and larger such that the supports shall resist the forces of a Seismic Factors event without collapse.
I. Provide seismic support and bracing for all busway and cable tray such that the support shall resist the forces of Seismic Factors event without collapse.

3.02 CONCRETE BASES:

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

3.03 SUPPORTS:

A. Construct with sufficient rigidity to hold all mounted equipment and material in permanent and neat alignment.
B. Design to provide 1/4-inch space between equipment housings and walls or columns upon which they are mounted.
C. Do not exceed load requirements in NEC and NEMA standards.
D. Provide individual conduit hangers for supporting individual conduits.
E. Provide trapeze hangers to support multiple conduit runs. Use trapeze hangers that are designed to support a load equal to or greater than the sum of the weights of the conduits,

wires, hanger itself, and an additional 90 kg (200 lbs). Attach each conduit with U bolts or other approved fasteners.

F. Support conduit independently of junction boxes, pull-boxes, fixtures, suspended ceiling T bars, angle supports, and similar items.

G. Vertical Supports: Vertical conduit runs shall have riser clamps and supports in accordance with the NEC and as shown. Provide supports for cable and wire with fittings that include internal wedges and retaining collars.

H. For galvanized members after Power Tool Cleaning SSPC-SP11, paint all welds, field cuts, and damaged areas with organic zinc-rich primer at 3-mils dry film thickness.
   1. Ameron - 68HS.
   2. Carboline - Carbozinc 859.
   3. International - Interzinc 52 HS.
   4. Tnemec - Tnemezinc 90-97.

I. For coated supports, paint all welds, field cuts, and damaged areas with manufacturer's recommended paint.

J. Use epoxy- or acrylic-coated supports, clamps, and straps, and zinc-plated hardware to support steel conduit.

K. Use stainless-steel or PVC-coated conduit straps to support PVC-coated rigid steel conduit. Use stainless-steel clamps for supporting PVC coated rigid steel conduit on stainless-steel supports.

3.04 PAINTING:

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

B. Clean and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal as required.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION 26 05 29

SECTION 26 05 33 – RACEWAYS, BOXES, SEALS, AND FITTINGS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY:

A. This Section specifies raceway Work for this Contract.

B. Provide raceway and material including:

1. Conduit.
2. Outlet and device boxes.
3. Pull and junction boxes.
4. Fittings.
5. Bushings and ground bushings.
6. Locknuts.
7. Knockout closures.
8. Grout.

1.03 RELATED REQUIREMENTS:

A. SECTION 26 00 00 - General Electrical Requirements

B. SECTION 26 05 26 - Grounding and Bonding for Electrical Systems

C. SECTION 26 05 29 - Hangers and Supports for Electrical Systems

D. SECTION 26 05 44 - Sleeves and Sleeve Seals for Electrical Raceways and Cabling

E. SECTION 26 05 53 - Identification for Electrical Systems

1.04 REFERENCE STANDARDS:

A. Publication Dates: Comply with standards in effect as of the Issued For Construction (IFC) date of the Contract Documents unless otherwise indicated.

B. American National Standards Institute (ANSI):

1. ANSI C80.1 - Electrical Rigid Steel Conduit (ERSC).
2. ANSI C80.3 - Electrical Metallic Tubing – Steel (EMT-S).
3. ANSI C80.5 - Electrical Rigid Metal Conduit – Aluminum (ERMC-A).
4. ANSI C80.6 - Electrical Intermediate Metal Conduit (EIMC).

C. American Welding Society (AWS):

1. AWS D1.1/D1.1M - Structural Welding Code - Steel.

D. ASTM International (ASTM):

1. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
2. ASTM A153/A153M. - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
3. ASTM A240/A240M - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
4. ASTM A780/A780M - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
5. ASTM B117 -Standard Practice for Operating Salt Spray (Fog) Apparatus.

6. ASTM C1107/C1107M REV A - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink).
7. ASTM B241/B241M - Standard Specification for Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube.
8. ASTM D3917 REV A - Standard Specification for Dimensional Tolerance of Thermosetting Glass-Reinforced Plastic Pultruded Shapes.
9. ASTM D4385 - Standard Practice for Classifying Visual Defects in Thermosetting Reinforced Plastic Pultruded Products.
10. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
11. ASTM F2160 - Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD).

E. Joint Industrial Council (J.I.C.):
1. Comply with standards for Oil and Dust Tight Lay-In Wireway.

F. National Fire Protection Association (NFPA):
1. NFPA 70 - National Electrical Code (NEC).

G. National Electrical Contractor's Association (NECA):
1. NECA NEIS 1 - Standard for Good Workmanship in Electrical Construction.

H. National Electrical Manufacturers Association (NEMA):
1. NEMA RN 1 - Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
2. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit.
3. NEMA TC 3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
4. NEMA TC 6 and 8 - Polyvinyl Chloride (PVC) Plastic Utilities for Underground Installation.
5. NEMA TC 14.AG - Aboveground Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
6. NEMA TC 14.BG - Belowground Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
7. NEMA TC 14.XW - Extra Heavy Wall Aboveground Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
8. NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports.
9. NEMA OS 2 - Nonmetallic Outlet Boxes, Covers, and Box Supports.
10. NEMA 250 - Enclosures for Electrical Equipment (1,000V Maximum).

I. Society of Protective Coatings (SSPC):
1. SSPC-PA 1 - Shop, Field and Maintenance Painting of Steel.
2. SSPC-SP3 - Power Tool Cleaning.

J. Underwriters' Laboratories, Inc. (UL):
1. Provide all devices, components, and equipment that are UL listed and labeled.
2. UL 1 - UL Standard for Safety Flexible Metal Conduit.
3. UL 5 - UL Standard for Safety Surface Metal Raceways and Fittings.
4. UL 5C - UL Standard for Safety Surface Raceways and Fittings for Use with Data, Signal, and Control Circuits.
5. UL 6 - UL Standard for Safety Electrical Rigid Metal Conduit – Steel.
6. UL 6A - UL Standard for Safety Electrical Rigid Metal Conduit - Aluminum, Red Brass and Stainless Steel.

7. UL 50 - UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations.
8. UL 50E - UL Standard for Safety Enclosures for Electrical Equipment, Environmental Considerations.
9. UL 360 - UL Standard for Safety Liquid-Tight Flexible Metal Conduit.
10. UL 514A - UL Standard for Safety Metallic Outlet Boxes.
11. UL 514B - UL Standard for Safety Conduit, Tubing, and Cable Fittings.
12. UL 514C - UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers.
13. UL 651 - UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings.
14. UL 651A - UL Standard for Safety Schedule 40 and 80 High Density Polyethylene (HDPE) Conduit.
15. UL 797 - UL Standard for Safety Electrical Metallic Tubing – Steel.
16. UL 797A - UL Standard for Safety Electrical Metallic Tubing – Aluminum and Stainless Steel.
17. UL 1203 - UL Standard for Safety Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations
18. UL 1242 - UL Standard for Safety Electrical Intermediate Metal Conduit - Steel
19. UL 2024 - Optical Fiber Cable Raceway.
20. UL 2515 - UL Standard for Safety Aboveground Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

1.05 SUBMITTALS:

A. Product Data:
   1. Submit manufacturer's technical product data, including conduit ratings, specifications, recommended installation applications (i.e. horizontal bore, direct burry, open trench) and installation instructions, for each type of product required. Include data substantiating that materials complies with the Contract Documents.
   2. Submit manufacturer's data on supporting devices including catalog cuts, specifications, and installation instructions, for each type of support, anchor, sleeve, and seal.
B. Certifications:
   1. Submit certifications for personnel responsible for installing conduit and fittings with PVC coated jackets.

1.06 QUALITY ASSURANCE:

A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, Structural Welding Code - Steel.
B. Comply with NEC.
C. Installations shall follow standard practices of NECA NEIS 1.
D. Installers of the PVC-coated galvanized rigid conduit system shall be certified by the manufacturer and be able to present a valid, unexpired certified installer card prior to starting installation. All clamping, cutting, threading, bending, and assembly instructions given during the manufacturer’s certified installation training shall be followed.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS:

A. Rigid Galvanized-Steel Conduit (RGS):
   1. Allied Tube and Conduit, Atkore International.
   2. Western Tube and Conduit Corporation.
   3. Wheatland Tube Company, JMC Steel Group.
   4. Republic Conduit, Tenaris.

B. Fittings for Rigid Steel Conduit:
   1. Heavy-Duty Cast Malleable Iron Fittings:
      a. Appleton, Emerson Electric Company.
      b. Crouse-Hinds, Eaton.
      c. Thomas & Betts, ABB Group.
   2. Conduit Expansion and Deflection Fittings:
      a. O-Z/Gedney, Emerson Electric Company.
      b. Thomas & Betts, ABB Group.

C. Rigid Steel Conduit and Fittings with Bonded Polyvinyl Chloride (PVC) Jacket:
   1. OCAL, Thomas & Betts, ABB Group.
   2. Robroy Industries.

D. Rigid Polyvinyl Chloride (PVC) Conduit and Fittings:
   1. IPEX Inc.
   2. North American Specialty Products.
   3. Carlon, Thomas & Betts, ABB Group.
   4. Cantex Inc.

E. Liquid-Tight Flexible Metal Conduit:
   1. AFC Cable Systems, Atkore International.
   2. Anamet Electrical, Inc.
   3. Electri-Flex Company.
   4. Southwire Company, LLC.
   5. Thomas & Betts, ABB Group.

F. Flexible Metal Conduit:
   1. AFC Cable Systems, Atkore International.
   2. Anamet Electrical, Inc.
   3. Electri-Flex Company.
   4. Southwire Company, LLC.
   5. Thomas & Betts, ABB Group.

G. Outlet and Device Boxes:
   1. Appleton, Emerson Electric Company.
   2. Crouse-Hinds, Eaton.
   3. Killark, Division of Hubbell, Inc.
   4. Leviton Manufacturing Company, Inc.
   5. O-Z/Gedney, Emerson Electric Company.
   6. Thomas & Betts, ABB Group.

H. Pull and Junction Boxes:
   1. Metallic Indoor and Outdoor Boxes:
      a. B-Line, Eaton.
      b. Hoffman, nVent Electric, plc.
      c. Wiegmann, Hubbell Inc.

2. Fiberglass Boxes:
   a. Crouse-Hinds, Eaton, Krydon type.
   b. Schneider Electric, Krydon type.
   c. Hoffman, nVent Electric, plc.

I. Conduit Hubs and Bodies:
1. Appleton, Emerson Electric Company.
2. Myers Industries, Inc. (ITT).
3. Crouse-Hinds, Eaton.
4. O-Z/Gedney, Emerson Electric Company.
5. Thomas & Betts, ABB Group.

J. Fittings:
1. Crouse-Hinds, Eaton.
2. Appleton, Emerson Electric Company.
3. Thomas & Betts, ABB Group.

K. Bushings, Grounding Bushings, and Locknuts:
1. Arrow Hart, Eaton.
2. Appleton, Emerson Electric Company.
3. O-Z/Gedney, Emerson Electric Company.
4. Raco, Hubbell, Inc.
5. Steel City, Thomas & Betts, ABB Group.

L. Electrical Enclosures:
1. Hoffman, nVent Electric, plc.
2. Saginaw Control and Engineering.
3. Wiegmann, Hubbell, Inc.

M. Anchor Manufacturers: Subject to compliance with requirements, provide anchors of one of the following manufacturers.
1. Hilti, Inc.
2. B-line, Eaton.
3. Powers, DeWalt.
4. Red Head, ITW.
5. Unistrut, Atkore International.

N. Metal Channel System Manufacturers: Subject to compliance with requirements, provide channel system of one of the following manufacturers.
1. B-line, Eaton
2. Erico, nVent Electric, plc.
3. Kindorf, Thomas & Betts, ABB Group.
4. Power-Strut, Atkore International.
5. Superstrut, Thomas & Betts, ABB Group.
6. Unistrut, Atkore International.

2.02 DESIGN REQUIREMENTS:

A. Conduit:
1. Each length of threaded conduit furnished with coupling on one end and metal or plastic thread protector on other end.
2. Provide UL listed and labeled conduit, on each length, fittings, and accessories.

3. Sizes of conduit, fittings, and accessories as indicated, specified, or as required by Electrical Codes and Standards.

B. Supports: refer to SECTION 26 05 29.

2.03 RIGID GALVANIZED STEEL CONDUIT:

A. Raceway:
1. Conform to ANSI C80.1, and UL 6.
2. Mild ductile steel, circular in cross section with uniform wall thickness sufficiently accurate to cut clean threads.
3. Each length threaded on both ends with threads protected.
4. All scale, grease, dirt, burrs, and other foreign matter removed from inside and outside prior to application of coating materials.
5. Galvanized by the hot-dip process as follows:
   a. Interior and exterior surfaces coated with a solid, unbroken layer of 99% virgin zinc by dipping.
   b. Coating not to show fixed deposits of copper after four 1-minute immersions in a standard copper sulfate solution.
   c. One coat of zinc-chromate finish on inside and outside surfaces to prevent oxidation and white rust.
6. Couplings and elbows fabricated, coated and finished by the same process as conduit.

B. Fittings:
1. Heavy-Duty Cast Malleable Iron Fittings:
   a. Mogul type for conduit sizes 1-1/2 inches and larger.
   b. LBD or roller action type LB for right-angle fittings for conduit sizes 2 inches and larger.
   c. Full-threaded hubs and rubber-gasketed covers.
   d. Zinc, cadmium-plated, or bronze hardware bolts and screws for assembly.
   e. Finished with cadmium plating or galvanizing.
   f. Form 8 bodies and covers.
   g. Standard and junction fittings.
2. Conduit Expansion Fittings:
   a. Line of Conduit Type:
      (1) Galvanized expansion fittings for rigid conduit movement up to 4 inches.
      (2) Insulated metal bushing on ends of the conduit, bonding jumper, and with expansion head sealed with a high-grade graphite packing.
      (3) O-Z/Gedney, Type AX with Type AJ bonding jumper or Thomas & Betts, Type XJG.
   b. End Type:
      (1) For conduit terminating in a junction box.
      (2) O-Z/Gedney, Type EXE with Type BJ-E bonding jumper.
3. Conduit Expansion and Deflection Fittings:
   a. Provide for movement of 3/4 inch from normal in all directions between two rigid conduits.
   b. Integral bonding jumper.
   c. O-Z/Gedney, Type DX.
4. Conform to NEMA Type 1 enclosure in all nonhazardous areas except as specified or indicated otherwise.

2.04 RIGID STEEL CONDUIT AND FITTINGS WITH BONDED POLYVINYL CHLORIDE (PVC) COATING:

A. General:
   1. The PVC coated conduit system is specifically designed to prevent corrosive conditions from causing early replacement of the conduit. All the conduit, fittings, and supporting products shall be provided by a single manufacturer.
   2. Installers of the PVC-coated galvanized rigid conduit system shall be certified by the manufacturer and be able to present a valid, unexpired certified installer card prior to starting installation. All clamping, cutting, threading, bending, and assembly instructions given during the manufacturer's certified installation training shall be followed.

B. Raceway:
   1. Conform to hot-dipped galvanized rigid steel conduit as specified in RIGID STEEL CONDUIT, this Section, and as follows. Shall comply with NEMA RN1.
   2. PVC coating bonded to the conduit. Extruded PVC jackets are unacceptable.
   3. Coated externally with PVC to a nominal 40 mils, 0.035 inch to 0.045 inch.
   4. Uniformly coated around outside diameter and full length of the conduit.
   5. Pre-threaded ends coated with a urethane coating having a nominal thickness of 2 mils (0.002 inch).
   6. Interior surfaces of all conduits and feed-through fittings coated (except where prohibited by design) with a two-part, chemically cured, urethane coating having a nominal thickness of 2 mils (0.002 inch).
   7. The bond strength between the metal and coating must exceed the tensile strength of the coating.

C. Couplings, Elbows, and Fittings:
   1. Couplings, elbows, and other conduit fittings, boxes, cover plates, supports, hardware, and related items shall be treated and coated with the same process as conduit.
   2. Each coupling and fitting to include a PVC sleeve that overlaps the conduit.
   3. Length of the overlapping sleeve equals diameter of the conduit or 2 inches, whichever is least.
   4. Final cured PVC coating capable of withstanding a minimum electrical potential of 2,000V.
   5. All conduit accessories, clamps, and hardware that are uncoated shall be stainless steel.
   6. All fittings intended for wet, outdoor, or wash-down application shall carry a NEMA 4X water-tight rating or have an equivalent v-seal design.
   7. Form 8 bodies and covers.

2.05 RIGID POLYVINYL CHLORIDE (PVC) CONDUIT:

A. Fabricated from self-extinguishing high-impact polyvinyl chloride designed for aboveground and underground installations.
B. Shall meet NEMA TC2, TC6 and TC8, and UL 651.
C. Type EPC Schedule 40 and Schedule 80 heavy-wall rigid conduit.
D. Fittings and accessories fabricated from same material as conduit. Shall meet NEMA TC3.
E. Solvent-cement-type joints as recommended by manufacturer.

2.06 LIQUID-TIGHT FLEXIBLE METAL CONDUIT:

A. Liquid-tight conduit with flexible galvanized-steel core and a synthetic rubber, polyvinyl chloride, or thermoplastic covering.
B. Shall comply with UL 360.
C. Spiral encased copper bonding conductors for conduit in sizes 1-1/4 inches and smaller.
D. External grounding jumper as required.
E. Provide hot-dipped galvanized fittings for connections to rigid steel conduit, and aluminum- or PVC-coated fittings for connections to aluminum and PVC-coated rigid steel conduit.
F. Fittings for liquid-tight flexible metal conduit shall comply with UL 514B.
G. Polyvinyl chloride (PVC) jacket, "Hi-Temp Liquatite Type H.T. Electri-Flex" where installed in a low or high temperature area, -40ºF, or high 220ºF, as specified or indicated.
H. Polyvinyl chloride (PVC) jacket, Type HA or Type O.R. "Seal-Tite" for oil-resistant applications.

2.07 FLEXIBLE METAL CONDUIT:

A. Spiral wound steel.
B. Reduced wall.
C. Shall be UL 1 listed.
D. Fittings for flexible metal conduit shall comply with UL 514B.

2.08 OUTLET AND DEVICE BOXES:

A. Surface Mounted:
   1. Cast hub device boxes for receptacles and switches.
   2. Cast malleable iron as applicable to match connecting conduit. Metallic boxes shall meet UL 514A and NEMA OS 1.
   3. PVC boxes for PVC conduit. PVC boxes shall meet UL 514C and NEMA OS 2.
   4. FS or FD single or multiple gang boxes as required.
   5. Outlet boxes intended for use in classified areas shall be UL 886 listed.
B. Flush Mounted in Plaster Walls:
   1. Galvanized, flat-rolled, sheet-steel gangable device boxes.
   2. Conduit knockout openings in bottom and sides.
   3. Threaded screw holes for fastening devices and box covers.
   4. Corrosion-resistant screws for equipment grounding.
   5. Include mounting brackets, device extensions plaster ears, and plaster board expandable grip fasteners (for existing plaster walls) compatible with box.
   6. Shall meet UL 514A and NEMA OS 1.

2.09 PULL AND JUNCTION BOXES:

A. Steel Boxes - Indoors:
   1. Hot-dipped galvanized steel.
   2. Galvanized-steel covers.
   3. Cadmium-plated or bronze screws and bolts.
   4. For special boxes where it is not possible to provide hot-dip galvanizing, apply organic zinc-rich primer at 3-mils dry film thickness after SSPC-SP3 Power Tool Cleaning.
   5. Minimum gauge requirements:

No surface No single

area exceeds	dimension exceeds	Gage steel
1,000 sq. inches	40 inches	14
1,500 sq. inches	60 inches	12
over 1,500 sq. inches	over 60 inches	10

6. Minimum of 14-gauge steel.
7. Conform to NEMA Type 1 enclosure in all nonhazardous areas except as specified or indicated otherwise.
   a. Junction boxes may be standard type with knock outs except as indicated otherwise.
8. Include piano-hinged, gasketed cover and interior mounting panel where oil-tight J.I.C boxes are used for enclosing terminal blocks and control relays.
9. Waterproof hubs in areas subject to moisture as indicated.

B. Steel Boxes - Outdoor:
1. 11-gauge minimum galvanized steel with drip lip and galvanized-steel covers fastened with bronze or cadmium-plated screws or bolts, or cast iron with galvanized finish and flanged bolted covers.
2. For special boxes where it is not possible to provide hot-dip galvanizing, apply organic zinc-rich primer at 3-mils dry film thickness after SSPC-SP3 Power Tool Cleaning.
3. Threaded conduit entrances or rigid conduit hubs on all boxes.
4. Rubber or neoprene gasket for cover.
5. Conform to NEMA Type 3R enclosure in all outdoor installations unless indicated otherwise.
6. Conform to NEMA Type 4 enclosure where indicated or specified.
7. Cast NEMA Type 4 in lieu of sheet steel.
8. Include piano-hinged, gasketed cover, and interior mounting panel when used for enclosing terminal blocks and control relays.
9. Oil-tight J.I.C boxes modified for NEMA Type 3R or Type 4 enclosure.

C. Stainless Steel Boxes - Outdoor:
1. Type 304 or 316 stainless steel with stainless-steel cover and stainless-steel clamps and screws.
2. Minimum 16 gauge for boxes with no dimension exceeding 6 inches and minimum 14 gauge for all other boxes.
3. Continuously welded seams shall be ground for a smooth finish.
4. Seamless gasket for cover.
5. Conform to NEMA Type 4X.
6. Provide continuous hinge, gasketed cover, and interior mounting plate when used for enclosing terminal blocks and control relays.
7. Provide rigid weatherproof conduit hubs for all boxes.

D. Metallic Barriers:
1. Designed not to separate phases of a power circuit.
2. Provide as indicated for the isolation of power circuits from other type circuits

E. Bushings: Provide threaded, nylon-insulated metallic bushings. Provide steel bushings for conduit sizes 1-1/2 inches and smaller. Provide malleable iron bushings for conduit sizes 2 inches and larger.
F. Grounding Bushings: Provided where indicated, specified and required by NEC. Provide threaded, insulated, malleable iron bushing with lay-in screw clamp lug.
G. Locknuts: Provide steel locknuts for conduit sizes 2 inches and smaller. Provide malleable iron for conduit sizes 2.5 inches and larger. Locknut material shall match conduit type.
H. Sealing Hub: Provide watertight, threaded, insulated sealing hub connectors for all outdoor and indoor wet locations where conduit enters into enclosures. Sealing hub threaded lengths shall be adequate to allow installation of bushing.
I. Knockout Closures: Provide steel press-in knockout seals for all unused punched out knockouts 2 inches and smaller. Provide steel two-piece bolt on knockout seals for all unused punched out knockouts 2-1/2 inches and larger.
J. Fittings: Provide all threaded nipples, insulated short elbows, offset nipples, offset connectors, enlargers and reducers as required.
K. Hinged-Cover Enclosures:
    1. Comply with UL 50 and NEMA 250, Type 12 for indoor and Type 3R or 4X for outdoor.
    2. Provide with continuous-hinge cover with flush latch unless otherwise indicated.
    3. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
    4. Nonmetallic Enclosures: Plastic.
    5. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
    6. Metal barriers to separate wiring of different systems and voltage.
    7. Gasketed enclosures shall meet UL 50E.

2.10 SUPPORT SYSTEM:
A. Provide as Specified in SECTION 26 05 29.

2.11 WALL AND DUCT SEAL:
A. Provide as specified in SECTION 26 05 44 for sleeves, seal fittings, silicone sealants and duct seal.

2.12 GROUT:
A. Description: Non-shrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
C. Design Mix: 5,000-psi (34.5-MPa), 28-day compressive strength.
D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.01 GENERAL
A. Comply with manufacturer's published instructions.
B. Follow the applicable NECA NEIS articles for installation of all conduit.
C. Provide stub-ups through floors with coupling threaded inside for plugs, set flush with finished floor. Prior to pouring concrete plug coupling until conduit is extended above floor to final destination or a minimum of 2 ft above finished floor.

D. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
E. Cut conduit perpendicular to the length. Use roll cutter or a guide to make cut straight and perpendicular to the length. Ream inside of conduit to remove burrs.
F. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound that maintains electrical conductivity to threads of duct raceway and fittings before making up joints. Follow compound manufacturer's published instructions.
G. Install firestopping at all conduit penetration of fire-rated walls, ceilings, and floors. Firestopping system shall equal or exceed fire rating of wall, ceiling, or floor in which it is installed.
H. Clean out all conduits before pulling wire.
I. Clean out all conduits immediately after concrete work is finished.
J. Install pull wires in empty duct raceways. Provide polypropylene or monofilament plastic line with not less than 200 lb tensile strength. Leave at least 12 inch of slack at both ends of pull wire. Cap underground duct raceways designated as spare above grade alongside duct raceways in use.

3.02 RACEWAYS INSTALLATION:

A. General Requirements:
1. Location:
a. Install conduit as near as possible to the routing indicated.
b. Shift locations as required to avoid interference with other equipment and piping being installed.
c. Route raceway so stubs up are located according to the equipment submittals next to indicated equipment connections or motor terminal boxes.
d. Where routing of conduit is not indicated, such as for lighting home run circuits and other systems requiring small conduit runs, route conduit as specified subject to approval by Engineer.
2. Install horizontal runs as high above floor as possible, and in no case lower than 7 feet above floor, walkway, or platform in passage area.
3. Run conduit parallel or perpendicular to walls, ceiling, beams, and columns unless indicated otherwise.
4. Follow manufacturer's recommendations for field bending of conduit or use conduit fittings provided by manufacturer.
5. Route to clear all doors, windows, access wells, and openings.
6. Group parallel runs in neatly aligned banks where possible with minimum of 1-inch clearance between exposed conduits and three conduits OD between concealed or encased conduits.
7. Do not install duct raceways or electrical items on "explosion-relief" walls or rotating equipment.
8. Do not install conduits within 2 inch of the bottom side of a metal deck roof.
9. Maintain 6-inch clearance between conduit and coverings on all hot lines; steam, hot water, and the like.
10. When terminating at cable tray, firmly attach conduit to tray and electrically bond conduit with ground wire to cable tray.

11. Do not use conduit in sizes smaller than 3/4 inch, except 1/2 inch may be used for connections to control devices and thermocouples where necessary.
12. Route the raceway through wall floor and ceiling penetrations, provide holes and sleeves as specified in SECTION 26 05 44.
13. Complete duct raceway installation before starting conductor installation.
14. Install no more than equivalent of three 90-degree bends in conduit run. Support within 12 inch of changes in direction.
15. Make bends in duct raceway using large-radius preformed ells except for parallel bends. Field bending must be in accordance with NFPA 70 minimum radii requirements. Provide only equipment specifically designed for material and size involved.
16. Make connections to boxes, panels, and other equipment as follows:
    a. Indoor Dry Locations: Double locknuts, one inside and one outside.
    b. Outdoor and Damp Locations: Rigid weatherproof conduit hubs.
    c. Bushings:
        (1) Threaded malleable iron or steel.
        (2) Insulated with Bakelite, molded and bonded into the bushing.
        (3) Placed on end of conduit in addition to locknuts.
        (4) Install with integral grounding connector and conductor where all conduits pass through multiple concentric panel knockouts and where the conduit must be bonded to equipment it is not attached to.
17. Running threads will not be permitted.
18. Coat all field cut threads in galvanized conduit with cold galvanizing paint.
19. Comply with applicable requirements of NEC pertaining to installation of conduit systems.
20. Place drainage fittings or weep holes at unavoidable low points where moisture can collect.
21. Install an entire conduit system that is electrically continuous with bonding jumpers provided as necessary to conform to NEC.
22. Install expansion fittings at all building expansion joints and every 100 feet of continuous conduit.
23. Flattened, dented, or deformed conduit is not permitted. Remove and replace the damaged conduits with new conduits.
24. Provide identification of all raceways, including conduit and wireways as specified in Section 26 05 53.
25. Ground all raceways as specified in Section 26 05 26.

B. Rigid Steel Conduit:
    1. Install exposed in building interior spaces or above grade outdoors.
    2. Concealed:
        a. Install conceal conduit for lighting, convenience outlets, and other circuits in walls, ceiling, and floors where possible.
        b. Do not install conduit in concrete where conduit outside diameter exceeds one-third of concrete thickness.
        c. Use expansion and deflection fitting with bonding jumpers at all concrete expansion joints.
        d. Tie securely in place to prevent movement when concrete is poured.
        e. Install in floor slabs in as straight a run as possible. Conduit crossovers are not permitted unless conduit total outside diameter is one-third of the concrete thickness or less.

C. PVC-Coated Rigid Steel Conduit:
   1. Install in areas specified as corrosive, wet and damp or where indicated.
   2. Installers of PVC Coated Conduit must be certified by the manufacturer and be able to present a valid, unexpired Certified installer card prior to installation of conduit system.
   3. Coat field cut threads with manufacturer's standard product in accordance with manufacturer's recommendations.
   4. Use bender one size larger for conduit sized 1 inch or less and conventional bender for conduit sized above 1 inch.
   5. Use strap wrench to tighten conduit. Repair damaged coating with liquid patching compound recommended by conduit manufacturer.
   6. Buried:
      a. Install in as straight a run as possible between termination points of exact routing to be determined in the field and subject to approval by Engineer.
      b. Bury conduits a minimum of 30 inches below finish grade unless indicated otherwise.
      c. Slope conduit away from building conduit risers down to handholes or manhole drains.
      d. Maintain 6-inch separation from underground piping.
      e. Use for conduit risers where routed through concrete slabs.
      f. After trench bottom has been finished to grade, lay conduit. Backfilling shall be as specified in Division 31.
      g. Cap ends of all conduit risers before backfilling.

D. Rigid PVC Conduit:
   1. Install RGS above ground exposed or in underground services or concrete encasement, except where PVC coated is provided for ells and risers to prevent burn through or where indicated.
   2. Make all joints watertight with cement compound furnished by the conduit manufacturer.
   3. Buried:
      a. Install in as straight a run as possible between termination points of exact routing to be determined in the field and subject to approval by Engineer.
      b. Bury conduits a minimum of 30 inches below finish grade unless indicated otherwise.
      c. Slope conduit away from building conduit risers down to handholes or manhole drains.
      d. Maintain 6-inch separation from underground piping.
      e. Use PVC-coated rigid steel elbows at all risers and at any bend greater than 45 degrees unless indicated otherwise.
      f. All risers shall be PVC-coated rigid steel conduit.
      g. After trench bottom has been finished to grade, lay conduit. Backfilling shall be as specified in Division 31.
      h. Cap ends of all conduit risers before backfilling.

E. Liquid-Tight Flexible Metal Conduit.
   1. Use between rigid conduit and motor terminal boxes except where conduit runs down from above and cannot be conveniently supported by a floor flange.

2. Place between rigid conduit or conduit box and control device cases where direct connection is not desirable for reasons of equipment movement, vibration, or for ease of maintenance.
3. Install at all points of connection to equipment mounted on supports to allow for expansion and contraction.
4. Conform to NEC with installation of conductors.
5. Install at locations where rigid conduit connections are impractical.
6. Use minimum length consistent with manufacturer's standard lengths, the acceptable bending radius, and with required movement of equipment.
7. Maximum length of 3 feet unless otherwise approved by Engineer.
8. Install an external bonding jumper to conform to NEC on conduit sized 1-1/2 inches and larger.
9. Install flex conduit with 15% extra length to allow the conductors and conduit room for vibration and expansion.

F. Conduit Fittings:
1. Installations of special fittings are indicated.
2. Use aluminum fittings for joining aluminum to steel conduit.
3. Install as required.

3.03 BOXES AND FITTINGS:

A. Install electrical boxes, bushings, locknuts, nipples, connectors, sealing hubs, and fittings as required, indicated, in accordance with applicable requirements of NEC and in accordance with recognized industry practices to fulfill Project requirements.
B. Coordinate installation of electrical boxes and fittings with wire/cable, wiring devices, and raceway installation work.
C. Provide weatherproof boxes for interior and exterior locations exposed to weather or moisture.
D. All boxes containing emergency power and lighting circuits shall be identified as specified in Section 26 05 53 - Electrical Identification.
E. Provide (oil-tight) knockout closures to cap unused knockout holes where blanks have been removed.
F. Install electrical boxes in only those locations which ensure ready accessibility to enclosed electrical wiring.
G. Maximum box size in a fire-rated wall shall be 4 inches by 4 inches square. Do not install boxes back-to-back in walls. In walls that are not fire-rated or acoustic- rated, provide not less than 6 inches (150 mm) horizontal separation between boxes installed in opposite sides of wall. Provide not less than 24 inches (610 mm) horizontal separation between boxes installed in opposite sides of fire-rated and acoustic-rated walls.
H. Do not install aluminum products in concrete.
I. Position recessed outlet boxes accurately to allow for surface finish thickness.
J. Set floor boxes level and flush with finish flooring material.
K. Fasten electrical boxes firmly and rigidly to the surfaces to which attached, structural surfaces to which attached, or solidly embed them in concrete or masonry.
L. Provide electrical connections for installed boxes.
M. Properly ground metallic electrical boxes in compliance with the NEC. Bond all non-isolated equipment grounding conductors to all electrical boxes.
N. Subsequent to installation of boxes, protect boxes from construction debris and damage.
O. Install special boxes as indicated of size required for conduits and cables entering and leaving box.

P. Explosionproof Fittings:
   1. Install explosionproof fittings in the conduit system as required by NEC.
   2. Install necessary fittings where not indicated but required by code.

Q. Ground boxes and fittings per SECTION 26 05 26 - Grounding.

3.04 PAINTING:

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

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION 26 05 33

SECTION 26 05 43 – UNDERGROUND DUCT BANKS AND HANDHOLES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY:

A. This Section includes the following:
   1. Complete underground duct systems consisting of banks of nonmetallic ducts encased in reinforced concrete.
   2. All necessary earth and rock excavation and backfill.
   3. Removal and disposal of all excess excavation material.

1.03 RELATED REQUIREMENTS:

A. SECTION 26 00 00 - General Electrical Requirements
B. SECTION 26 05 26 - Grounding and Bonding for Electrical Systems
C. SECTION 26 05 33 - Raceway and Boxes for Electrical Systems
D. SECTION 26 05 53 - Identification for Electrical Systems

1.04 REFERENCE STANDARDS:

A. American Concrete Institute (ACI):
   1. 318-14 – Building Code Requirements for Structural Concrete.
B. American Society for Testing and Materials (ASTM):
   1. A48 – Standard Specification for Gray Iron Castings.
   2. C857 – Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
   3. C858 – Standard Specification for Underground Precast Concrete Utility Structures.
   4. D3917 – Dimensional Tolerance of Thermosetting Glass Reinforced Plastic Pultruded Shapes.
   5. D4385 – Practice for Classifying Visual Defects in Thermosetting Reinforced Plastic Pultruded Products.
   6. F512 – Standard Specification for Smooth Wall Polyvinyl Chloride (PVC) Conduit and Fittings for Underground Installation.
C. Federal Specifications:
   1. W-C-1094A – Conduit and Conduit Fittings Plastic, Rigid.
D. National Electrical Manufacturer's Association (NEMA):
   1. TC-2 – Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80).
   2. TC 6 – PVC and ABS Plastic Utilities Duct for Underground Installation.
   3. TC 8 – Extra Strength PVC Plastic Utilities Duct for Underground Installation.
   4. TC-14 – Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
E. Underwriters Laboratories, Inc. (UL):
   1. 651 – Schedules 40, 80, Type EB and A Rigid PVC Conduit and Fittings
   2. 651A – Schedule 40 and 80 High Density Polyethylene (HDPE) Conduit.
   3. 1684 – Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

1.05 SUBMITTALS:

A. Product Data: Submit the following for each type of product specified and included as minimum:
   1. Data sheets for each product supplied.

B. Shop Drawings: Provide the following as minimum:
   1. Submit shop drawings for fabrication and installation of pre-cast concrete structures and cast-in-place concrete structures including the following:
      a. Steel reinforcement drawings.
      b. Elevation showing openings, pulling irons, cable supports, sump, steps, covers, frames and other details.
C. Closeout Submittals: Final documentation shall include the following as minimum:
   1. Certified "As-Built"/"As-Installed" drawings.
   2. Copies of all approved Product Data.

1.06 QUALITY ASSURANCE:

A. Manufacturer Qualifications:
   1. The manufacturer shall be by a company specializing in providing precast products and services normally associated with precast-concrete construction. Design of precast handholes shall be prepared by a professional engineer licensed in the state associated with the project to conform to the procedures set forth in ACI 318 and applicable standards of this specification and of the size, shape, and details indicated or specified.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

A. Ducts:
   1. Carlon.
   2. Certain-Teed.
   3. Cantex.
B. Duct Spacers:
   1. Carlon.
   2. CertainTeed.
   3. Formex.
   4. Cantex.
C. Concrete Inserts:
   1. Unistrut Corporation.
   2. B Line Systems, Inc.

2.02 DUCTS:

A. Conduit Types for Concrete Encasement:
   1. Schedule 40:
      a. Tested to Underwriters' Laboratories, Inc. (UL) Standard UL 651A.
B. Conduit Types for Direct Bury Applications:
   1. Schedule 80:
      a. Tested to Underwriters' Laboratories, Inc. (UL) Standard UL 651A.
C. Rated for use with 90°C conductors.
D. Provide with all necessary end bells, couplings, offset couplings, elbows, plugs, and other fittings.
E. Sizes as indicated.
F. Install PVC coated rigid galvanized steel elbows for all duct termination risers and all non-sweeping horizontal 90 degree bends.
G. Provide prefabricated, interlocking type plastic duct spacers for duct spacing as indicated.

2.03 REINFORCING STEEL:
- A. Provide as specified in Division 03.

2.04 CONCRETE:
- A. Provide as specified in Division 03.
- B. Red colored concrete encasement, where required, shall use a red pigment integrally mixed into the concrete. Dry shake or broadcast coloring agents are not to be used.

2.05 WARNING TAPE:
- A. Standard detectable warning tape, 4-mil-thick, 6-inch-wide tape, red with black letters imprinted with "CAUTION BURIED ELECTRIC CABLE BELOW".
- B. Provide high molecular weight polyethylene (HMWPE) insulated #12 AWG solid copper tracer wire.

2.06 "PULLING IN" ROPE:
- A. Nylon or nylon equivalent composite.
- B. Minimum average breaking strength: 2000 pounds.

PART 3 - EXECUTION

3.01 EXCAVATION AND TRENCHING FOR DUCT BANKS AND HANDHOLES
- A. Perform as specified in Division 31.
- B. Work with extreme care near existing underground utilities to avoid damaging them.
- C. Pitch the trench uniformly toward handholes or both ways from high points between handholes for required drainage.
- D. Notify the Owner's representative for inspection prior to any duct bank installation and prior to concrete placement.

3.02 INSTALLATION:
- A. Duct Banks:
  1. Ducts:
     - a. Assemble as follows:
       - (1) On spacers to maintain horizontal and vertical separation indicated.
       - (2) With joints in adjacent ducts staggered.
       - (3) All joints watertight by application of joint sealer compound furnished by duct manufacturer.
       - (4) No reinforcing steel or other ferrous material between individual ducts.
     - b. Securely tie overall at 5 foot or closer intervals as required.
     - c. Secure to anchors after assembling to prevent flotation when placing concrete.
     - d. Slope towards handholes with a minimum continuous slope of 1/2 percent.
     - e. Align ducts for each 100 feet not greater than 4 inches horizontal.
     - f. All risers, including elbows and non-sweeping horizontal bends shall be PVC coated rigid galvanized steel as specified.
     - g. Install end bells flush with face of concrete at each handhole and termination point unless indicated otherwise.
     - h. Immediately after cleaning, install a "pulling in" rope in each duct, and plug each end of all ducts.
  2. Install warning tape along the entire length of duct banks at a depth of 12 inches below grade or as indicated on drawings.

3. Run warning tape tracer wire to handhole with tracer wire test station.
4. Reinforcing: Place as specified in Division 03.
5. Concrete:
    a. Do not place prior to inspection and approval of duct and reinforcing installation by Engineer.
    b. Place as specified in Division 03.

B. Duct and Conduit Sealing:
1. Seal the ducts and conduits at building entrances and at outdoor equipment with a suitable non-hardening compound to prevent the entrance of moisture and gases.

3.03 BACKFILLING:

A. Provide backfill and compaction as specified in Division 31.

3.04 ADJUSTING AND CLEANING:

A. Rod and clean all ducts with suitable cleaners, swabs and mandrels after completion of the duct bank.

END OF SECTION 26 05 43

SECTION 26 05 44 – SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and DIVISION 01 Specification Sections, apply to this Section.

1.02 SUMMARY:

A. This SECTION specifies the sleaves and seals Work by this Contract.
B. Provide raceway and duct seals including:
   1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
   2. Sleeve-seal fittings.
   3. Seal fittings.
   4. Silicone sealants.
   5. Duct seal.

1.03 RELATED REQUIREMENTS:

A. SECTION 26 00 00 - General Electrical Requirements
B. SECTION 26 05 33 - Raceway and Boxes for Electrical Systems

1.04 REFERENCE STANDARDS:

A. ASTM International (ASTM):
   1. ASTM A 53/A 53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
   2. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
   3. ASTM C1107/C1107M - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
B. Joint Industrial Council (J.I.C.):
C. National Fire Protection Association (NFPA):
   1. 70 - National Electrical Code (NEC).
D. National Electrical Contractor’s Association (NECA):
   1. NECA NEIS 1 - Standard for Good Workmanship in Electrical Construction.
E. National Electrical Manufacturers Association (NEMA):
   1. NEMA VE 2 - Cable Tray Installation Guidelines

1.05 SUBMITTALS:

A. Product Data:
   1. Submit manufacturer's technical product data, including specifications and installation instructions, for each type of product required. Include data substantiating that materials comply with requirements.
   2. Submit manufacturer's data on supporting devices including catalog cuts, specifications, and installation instructions, for each type of support, anchor, sleeve, and seal.

1.06 COORDINATION:

A. Coordinate size and location of sleeves. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified together with concrete specifications.
B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS:

A. Wall Entrance Seals: O.Z./Gedney, Emerson Electric Company.
B. Duct Seal:
   1. Ideal Industries, Inc.
   2. The 3M Company.
   3. Engineer-approved equal.

2.02 SLEEVES:

A. Round Sleeves:
   1. Steel Wall Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
   2. Cast-Iron Wall Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
   3. PVC-Pipe Sleeves: ASTM D1785, Schedule 40.
   4. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.
   5. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
B. Rectangular Sleeves:
   1. Rectangular, galvanized-steel, sheet metal sleeves.
   2. Minimum Metal Thickness:
      a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
      b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.03 SLEEVE-SEAL SYSTEMS

A. Options:
   1. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   2. Pressure Plates: Stainless steel.
   3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.
B. General Characteristics: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit must have plastic or rubber waterstop collar with center opening to match piping OD.

2.04 GROUT:

A. Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
C. Design Mix: 5,000-psi (34.5-MPa), 28-day compressive strength.
D. Packaging: Premixed and factory packaged.

2.05 POURABLE SEALANTS

A. Single-component, neutral-curing elastomeric sealants of grade indicated below.

B. Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

2.06 FOAM SEALANTS

A. Multicomponent, liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam. Foam expansion must not damage cables or crack penetrated structure.

2.07 CONDUIT WALL ENTRANCE SEALS:

A. Provide where required or indicated.
B. Use O.Z./Gedney Company Type FSK for new walls.
C. Use O.Z./Gedney Company Type CSM for penetration in existing walls.

2.08 SEAL FITTINGS AND COUPLINGS FOR RIGID STEEL, ALUMINUM AND PVC-JACKETED RIGID STEEL CONDUIT:

A. Fittings:
   1. Cast malleable iron fittings (for rigid steel conduit).
   2. Cast aluminum fittings (for aluminum conduit).
   3. Explosionproof.
   4. Cast malleable iron.
   5. Threaded cover to conform to NEC.
   6. Full thread hubs.
   7. Seal compound well for seal.
   8. Drain seals as indicated or required to provide a continuous automatic drain of water.
   9. "Chico" compound for all sealing fittings.
   10. PVC jacketed in corrosive areas where PVC-jacketed conduit is used.
B. Couplings:
   1. Explosionproof.
   2. Flexible.
   3. Conform to NEC.
   4. Threaded steel end fittings securely fastened to the core and braided to ensure electrical continuity.
   5. PVC jacketed in corrosive areas where PVC-jacketed conduit is used.

2.09 DUCT SEAL:

A. Duct Seal:
   1. Noncorrosive, permanently soft compound.
   2. Nontoxic.
   3. Provide flexible re-enterable and repairable seal around cables in conduits.
   4. Prevent air movement and drafts through conduits.
   5. Provide Ideal Industries Duct Seal, 3M® Moldable Putty, or Engineer-approved equal.

2.10 SILICONE SEALANTS:

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
   1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.01 SEAL FITTINGS:

A. Comply with NECA 1.
B. Comply with NEMA VE 2 for cable penetrations.
C. Install duct sealing fittings at accessible locations in accordance with NFPA 70 and fill them with listed sealing compound. For concealed duct raceways, install fitting in flush steel box with blank cover plate having finish similar to that of adjacent plates or surfaces. Install duct sealing fittings in accordance with NFPA 70.
D. Install devices to seal duct raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal interior of duct raceways at the following:
    1. Conduits pass from warm to cold locations.
    2. Underground service duct raceway enters a building or structure.
    3. Conduit extending from interior to exterior of building.
    4. Around cables at all conduit terminations at control panels
    5. Boxes containing terminations and splices.
    6. Where otherwise required by NFPA 70
    7. Install necessary fittings where not indicated but required by code.
E. Wall, Roof and Floor Seals: Provide sleeves for conduit which penetrate foundation walls below grade, floors, ceilings, or exterior walls. Caulk between sleeve and conduit with nontoxic, UL-classified caulking material to ensure watertight seal.
F. Sleeve Seals: Provide modular mechanical type seals, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with bolts and pressure plates which cause rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation. Seal fire rating shall equal or exceed that of the wall or floor penetrated.
G. Provide a fire-rated sleeve and seal equal to or exceeding the fire rating of the ceiling, floor or wall being penetrated.
H. Provide through floors, walls, and roofs as necessary for conduit or cable tray runs, including approved flashing and weather proofing at outside walls and on roofs.
I. Install sleeves or forms for all openings in new Work.
J. Provide the required inserts and holes, completely sleeved, bonded, curbed, flashed, and finished off in an approved manner, whether in concrete, steel grating, metal panels, or roofs.
K. Core-drill all holes required in existing building work using a dustless method.
L. Place non-shrinking grout or Dow Corning 3-6548 Silicone RTV or equivalent General Electric RTF 762 sealant as specified, in the following locations:
M. All holes in concrete, walls, floor, and roof slabs after installation of conduit.
N. All unused holes and sleeves as approved by Engineer.
O. Install wall entrance seals where conduit enters the building or vaults from exterior underground.
P. Sleeves for Conduits Penetrating Above-Grade, Non-Fire-Rated, Concrete and Masonry-Unit Floors and Walls:
    1. Size pipe sleeves to provide 1/4 inch annular clear space between sleeve and raceway or cable, unless sleeve-seal system is to be installed.

2. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inch above finished floor level. Install sleeves during erection of floors.

Q. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve-seal systems. Size sleeves to allow for 1 inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

R. Underground, Exterior-Wall and Floor Penetrations:
   1. Install steel pipe sleeves with integral waterstops. Size sleeves to allow for 1 inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system. Install sleeve during construction of floor or wall.
   2. Install steel pipe sleeves. Size sleeves to allow for 1 inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system. Grout sleeve into wall or floor opening.

END OF SECTION 26 05 44

SECTION 26 05 53 – IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY:

A. This Section specifies electrical identification work including the following:
   1. Buried cable and duct bank warnings.
   2. Electrical power, control, and communication conductors (and raceways).
   3. Operational instructions and warnings.
   4. Danger, caution and warning signs.
   5. Equipment/system identification nameplates.

1.03 RELATED REQUIREMENTS:

A. Section 26 05 73 – Short-Circuit, Coordination and Arc-Flash Hazard Analysis Studies.

1.04 REFERENCE STANDARDS:

A. Applicable Standards: Comply with the applicable requirements of the following standards.
   1. American Society of Mechanical Engineers (ASME):
      a. A13.1 - Scheme for the Identification of Piping Systems.
   2. Federal Specifications (FS):
      a. FS L-P-387 - Polyethylene Low and Medium Density – Molding Material (for designation plates).
   3. National Electrical Manufacturers Association (NEMA):
      a. Z535.1 - Safety Colors.
      b. Z535.4 - Product Safety Signs and Labels.
   4. National Fire Protection Association (NFPA):
      a. 70 - National Electrical Code (NEC), as applicable to installation of identifying labels and markers for wiring and equipment.
      b. 70E - Electrical Safety in the Workplace.
      c. 72 - National Electric Safety Code (NESC) – IEEE C2.
   5. Occupational Safety and Health Administration (OSHA):
      a. 29 CFR 1910.144 - Safety Color Code for Marking Physical Hazards.
      b. 29 CFR 1910.145 - Specifications for Accident Prevention Signs and Tags.
   6. Underwriters Laboratories (UL), pertaining to electrical identification systems:
      a. 969 - Standards for Marking and Labeling Systems.

1.05 SUBMITTALS:

A. Product Data: Submit manufacturer's data on electrical identification materials and products.
B. Samples: Submit samples of each color, lettering style, and other graphic representation required for each identification material or system.

1.06 QUALITY ASSURANCE:

A. Comply with ASME A13.1 and IEEE C2.
B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
D. Comply with NEMA Z535.4 for safety signs and labels.
E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.07 COORDINATION:

A. Coordinate identification names, abbreviations, colors, and other features with requirements in other sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
C. Coordinate installation of identifying devices with location of access panels and doors.
D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

A. Subject to compliance with requirements, provide electrical identification products of one of the following (for each type marker):
1. Brady Worldwide, Inc.
2. Panduit Corp.
3. Seton Identification Products.
4. Thomas & Betts Corp.

2.02 ELECTRICAL IDENTIFICATION MATERIALS:

A. General: Except as otherwise indicated, provide manufacturer's standard products of categories and types required for each application. Where more than single type is specified for an application, selection is Installer's option; but provide single selection for each application.
B. Orange "Emergency" and "( )-VOLT" Conduit, Equipment, Box, and Cable Tray Markers:
1. General: Self-adhesive vinyl tape marker not less than 3 mils thick. Provide 1-1/8 inch wide by 4-1/2 inch long marker for 2 inch and smaller conduit. Provide 2-1/4 inch wide by 9 inch long marker for 2-1/2 inch and larger conduit and all cable tray. Except as otherwise indicated, provide black lettering which indicates highest voltage of cables(s) in conduit or cable tray. Provide black lettering that indicates "Emergency" power circuit is in conduit or cable tray.
2. Colors: Unless otherwise indicated or required by governing regulations, provide orange background tape marker.
C. Underground Type Plastic Line Marker:
1. General: Permanent, bright-colored, continuous-printed plastic tape marker, intended for direct-burial service; not less than 6 inches wide by 4 mils thick. Provide tape marker with printing which most accurately indicates type of service of buried cable or duct bank. (Provide embedded continuous metallic strip or core when used with non-metallic conduit and fiber optic cable to enable locating.)
D. Conduit, wireway and cable tray identification tags:
1. Instrument, 600V Control, and Power: Use labels with 2-inch black letters identifying cable tray number.

2. Label adhesive to be able to hold on curved surfaces and withstand temperatures up to 150ºF, in indoor or outdoor environments.
3. Labels to be resistant to oil, dirt, and abrasion.
4. A broad-tipped permanent ink-type marker shall be used to identify cable trays until the permanent labels are installed.
5. Made by Brady Corporation:
    a. Numbers generated with the BBP31 or BBP33 printer, with each raceway number on a continuous white background strip.
    b. Text size of 2 inches high with 1 character per inch on white background.
    c. Label size of 2.25 inches high.
    d. Utilize B-595 indoor/outdoor vinyl.
6. Made by Electromark Company:
    a. Each cable tray number generated on a continuous white background strip.
    b. C-1003 series.
    c. Label size of 2.5 inch high.
    d. Text size of 2 inches high with 1 character per inch on a white background of 6-mil polyester film.
    e. Suitable for outdoor installation in all environments.
        (1) Long lasting performance in all environments.
        (2) Permanent adhesive for cold weather installation.
        (3) UV resistant ink.
        (4) Furnish with wrap around bands to insure that the identification tags will not lift off.
7. Owner approved equal.

E. Wire/Cable Identification Bands:
1. General: Vinyl-cloth self-adhesive cable/conductor markers of wrap-around type, print-on type with clear plastic self-adhesive cover flap; numbered to show circuit identification number indicated on Drawings or Shop Drawings.

F. Plasticized Tags:
1. General: Preprinted or partially preprinted accident-prevention and operational tags, on plasticized card stock with matt finish suitable for writing, approximately 3-1/4 inches by 5-5/8 inches, with brass grommets and wire fasteners, and with appropriate preprinted wording, including large-size primary wording, e.g., "DANGER, DO NOT OPERATE." Tags shall comply with OSHA requirements.

G. Self-Adhesive Plastic Signs:
1. General: Self-adhesive or pressure-sensitive, preprinted, flexible vinyl signs for operational instructions or warnings; of sizes suitable for application areas and adequate for visibility, with proper wording for each application, e.g., "EXHAUST FAN."
    a. Colors: Unless otherwise indicated or required by governing regulations, provide white signs with black lettering.

H. Baked Enamel "Danger" Signs:
1. "DANGER" signs of baked enamel finish on 20-gauge steel (unless specified otherwise); of standard safety red, safety black, and safety white as defined by NEMA Z535.1; 14 inches by 10 inches size, except where 10 inches by 7 inches is the largest size which can be applied where needed, and except where larger size is needed for adequate vision; with recognized standard explanation wording, e.g., "_____VOLTS, KEEP AWAY." Sign shall conform to OSHA and NEMA Z535.4.

I. Baked Enamel "Caution" Signs:

1. "CAUTION" signs of baked enamel finish on 20-gauge steel (unless specified otherwise); of standard safety yellow with safety black letters; 14 inches by 10 inches size, except where 10 inches by 7 inches is the largest size which can be applied where needed, and except where larger size is needed for adequate vision; with recognized standard explanation wording, e.g., "Caution for Ear Protection Required in this Area."

J. Baked Enamel "WARNING" Signs:
1. "WARNING" signs of baked enamel finish on 20-gauge steel (unless specified otherwise); of standard safety orange with safety black letters; 14 inches by 10 inches size, except where 10 inches by 7 inches is largest size that can be applied where needed and except where larger size is needed for adequate vision; with recognized standard explanation wording. Sign shall conform to OSHA and NEMA Z535.4.

K. Engraved Plastic-Laminate Nameplates:
1. General: Engraving stock melamine plastic laminate nameplates, in sizes (minimum height of characters shall be 1/8 inch) and thicknesses specified or indicated, engraved with engraver's standard letter style of sizes and wording indicated, white face and black core plies (letter color) except as otherwise indicated, specified or required. Colors shall comply with OSHA and NEMA Z535.1. Nameplate shall be punched for mechanical fastening except where adhesive mounting is necessary because of the surface type it is mounted to, or where mechanical fastening will compromise the enclosure protection ratings.
   a. Thickness: 1/16-inch, for units up to 20 square inches or 8 inch length; 1/8-inch for larger units.
   b. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate surface it is mounted to.
2. Lettering and Graphics:
   a. Coordinate names, abbreviations, and other designations used in electric identification work with corresponding designations shown, specified, or scheduled. Provide numbers, lettering, and wording as indicated or, if not otherwise indicated, as recommended by manufacturer or as required for proper identification and operation/maintenance of electrical systems and equipment. Comply with ASME A13.1 pertaining to minimum sizes for letters and numbers. Comply with OSHA requirements. Comply with design requirements of NEMA Z535.4.

PART 3 - EXECUTION

3.01 APPLICATION AND INSTALLATION:

A. General Installation Requirements:
1. Install electrical identification products as indicated, in accordance with manufacturer's written instructions and requirements of NEC.
2. Coordination: Where identification is to be applied to surfaces which require finish painting, install identification after completion of painting.
3. Regulations: Comply with governing regulations and requests of governing authorities for identification of electrical work.

B. Conduit, wireway and cable tray identification tags:
1. General: Where exposed, apply identification markers at 20 foot intervals (visible from the floor) and within 3 feet of all panelboards, switchboards, switchgear, automatic transfer switches, emergency generators, substations, switches, devices, and circuit

breakers (readily visible when standing in front of equipment). Identification on wireway or cable tray shall be on outside of both sidewalls at 20 foot intervals.

C. Underground Cable, Conduit, and Duct Bank Identification Marker:
   1. General: During back-filling/top-soiling of each exterior underground direct buried electrical, signal or communication cable, conduit and duct bank, install continuous underground-type plastic line marker, located directly over the direct buried cable, conduit or duct bank at 12 inches below finished grade. Where multiple small direct buried cables are buried in a common trench and do not exceed an overall width of 16 inches, install a single line marker.
   2. Install line marker for every cable below grade, regardless of whether direct-buried, protected in conduit, or conduit in duct bank.

D. Wire/Cable Identification Bands:
   1. General: Apply cable/conductor identification bands, including circuit number, on each wire/cable in each box/enclosure/cabinet where wires of more than one circuit or communication/signal system are present. Match identification with marking system used in panelboards, shop drawings, contract documents, and similar previously established identification for project's electrical work.

E. Operational Identification and Warning Plasticized Tags and Metal Signs and Plastic Signs:
   1. General: Wherever reasonably required to ensure safe and efficient operation and maintenance of electrical systems, and electrically connected mechanical systems and general systems and equipment, including prevention of misuse of electrical facilities by unauthorized personnel, install signs with instruction or warnings. When signs are installed on switches, outlets, controls, devices and covers of electrical enclosures they may be self-adhesive vinyl or plastic. Where detailed instructions or explanations are needed, provide plasticized tags with clearly written messages adequate for intended purposes.
   2. Where switchboards, switchgear, motor control centers, and panelboard are supplied by a feeder, provide an informational sign indicating each device or piece of equipment from where the power originates.

F. Danger Signs:
   1. General: In addition to installation of danger signs specified, indicated, and required by governing regulations and authorities, install appropriate danger signs at locations indicated and at locations subsequently identified by Installer of electrical work as constituting similar dangers for persons in or about Project.
   2. XXXX Volts: Install danger signs (with actual circuit voltage) on all building doors, substations, switchgear, switchboards, panelboards switches, circuit breakers, etc., wherever it is possible (under any circumstances) for persons to come into contact with electrical voltages to ground greater than 277V.
   3. Critical Switches/Controls: Install danger signs on switches and similar controls, regardless of whether concealed or locked up, where untimely or inadvertent operation (by anyone) could result in significant danger to persons or damage to or loss of property.
   4. Provide the following danger sign on the equipment indicated:
      a. "Danger This Machine Starts Automatically" on all fire pumps, air compressors and emergency generators.

G. Warning Signs:
   1. Provide cable tray warning signs with 1-1/2-inch high black letters on an orange background that reads: "Warning! Not to be used as a walkway, ladder or support for ladders for personnel." Provide on each side of cable tray at 10-foot intervals, visible from the floor below.

2. Provide Arc Flash Warning signs on electrical equipment such as switchboards, switchgear, panelboards, industrial control panels, motor control centers and meter socket enclosures that are likely to require examination, adjustment, servicing, or maintenance while energized. Marking shall be permanently affixed and of a durable nature to withstand the environment within which it is installed.
3. Provide Available Fault Current Warning signs on electrical equipment as specified in Section 26 05 73. Label shall include possible incident energy exposure within arc flash boundary in front of equipment as well as meet NFPA 70E for additional content.

H. Equipment/System Identification Nameplates:
1. General: Install engraved plastic-laminated nameplates on each major unit of electrical equipment in the building; including central or master unit of each electrical system including communication/control/signal/alarm systems, unless unit is specified with its own self-explanatory identification or signal system. Except as otherwise indicated, provide single line of text, 1/2-inch high lettering on 1-1/2-inch high sign (2 inches high were two lines are required), black lettering on white field. Provide text matching terminology and numbering of the contract documents and shop drawings. Nameplate shall include unit designation, normal source circuit number ("Fed from..."), circuit voltage, and other data specifically indicated. Nameplate shall indicate normal source circuit number ("Fed from..."), and emergency source circuit number ("Fed from..."), when the equipment is a transfer switch or fed directly from a transfer switch. Provide nameplates for each unit of the following categories of electrical work:
   a. Disconnect switches.
   b. Push buttons, selector switches, indicating lights. (Circuit number and voltage not required on nameplate).
   c. Transformers (Include primary voltage, secondary voltage, number of phases, feeder, and panelboards or equipment supplied by the secondary.)
   d. Uninterruptible power supplies (UPS).
   e. Wireway used as auxiliary gutter tap locations with circuit number of circuit being tapped. Provide on outside of wireway.
   f. Provide "EMERGENCY" conduit markers on all conduit and pull boxes that contain emergency power conductors.
2. Install markers, tags, nameplates, and signs at locations indicated or, where not otherwise indicated, at location for best convenience of viewing without interference with operation and maintenance of equipment. Secure the identification with fasteners, except use adhesive where fasteners should not or cannot penetrate surface.

END OF SECTION 26 05 53

SECTION 26 05 73 – SHORT-CIRCUIT, COORDINATION AND ARC-FLASH HAZARD ANALYSIS STUDIES

PART 1 - GENERAL

1.01 SUMMARY:

A. This SECTION includes computer-based fault-current (short circuit) analysis, overcurrent protective device coordination, and arc flash hazard studies.
B. Perform field data collection, include cable length and enclosure sizes types and electrode configuration.
C. Perform fault-current (short circuit) analysis, overcurrent protective device coordination, and arc flash hazard studies.
D. The study shall be provided for the new work included in this project. The Contractor shall use Owner provided existing ETAP study/model to build upon.

1.02 RELATED REQUIREMENTS:

A. SECTION 26 05 53 – Identification for Electrical Systems.

1.03 REFERENCE STANDARDS:

A. The short circuit study shall be completed in accordance with the latest edition of the following standard:
   1. IEEE 3002.3-2018 - Recommended Practice for Short-Circuit Calculations in Industrial and Commercial Power Systems.
B. The short circuit study and overcurrent protective device coordination and settings shall be completed in accordance with the latest edition of the following standards:
   1. IEEE 3001.5-2013 - IEEE Recommended Practice for the Application of Power Distribution Apparatus in Industrial and Commercial Power Systems
   2. IEEE 3004.5-2014 - Recommended Practice for the Application of Low-Voltage Circuit Breakers in Industrial and Commercial Power Systems.
   3. IEEE 3004.11-2019 - Recommended Practice for Bus and Switchgear Protection in Industrial and Commercial Power Systems.
C. The arc flash hazard analysis and labels shall be completed in accordance with latest editions of the following standards:
   1. IEEE Standard 1584 - Guide for Performing Arc-Flash Hazard Calculations.
   2. NFPA70E – Standard for Electrical Safety Requirements for Employee Workplaces.

1.04 PERFORMANCE/DESIGN CRITERIA:

A. The short circuit study shall calculate the available short-circuit current at each bus in the electrical distribution system.
B. All overcurrent protective devices shall have an interrupting rating equal to or greater than the available short-circuit current at the point of application.
C. The study shall examine proper protection of electrical system components and utilization equipment such that the equipment has a sufficient short-circuit current rating.
D. The overcurrent protective device study shall analyze the system for selective coordination. This analysis shall identify any potential selective coordination problems including fault currents up to the available short-circuit current. Any areas where the overcurrent protective devices are not selectively coordinated shall be explicitly noted and recommendations shall be made to achieve selective coordination.
E. The study shall include an arc flash hazard analysis for electrical distribution equipment. The analysis shall determine the flash protection boundary, incident energy, and required level of personal protective equipment (PPE) for workers at the electrical distribution equipment. The

electrical distribution equipment shall be labeled with this information in accordance with codes, standards and the Owners existing arc flash hazard system.

1.05 SUBMITTALS:

A. Product Data:
   1. Computer analysis software application name, provider and version.

B. The results of the studies shall be summarized in report format with explanation of how to interpret the data.

C. As a minimum the report shall include the following:
   1. Short-Circuit Study:
      a. Printout of input data and calculated results.
      b. One-line diagram identifying all bus locations and the maximum available three-phase and line-to-ground short-circuit currents at each bus.
      c. Bus-to-bus listing of the maximum available short-circuit current expressed in RMS symmetrical amperes and the X over R ratio of that fault current.
      d. A table of specified equipment short-circuit ratings versus calculated short-circuit current values with notations of locations where are specified equipment short-circuit ratings are less or greater than required at the point of application.
      e. An analysis of the results in which any overrating or inadequacies shall be called to the attention of the Engineer and recommendations made for improvements.
   2. Protective Device Coordination Study:
      a. Time-current characteristic curve drawings on log-log printouts which illustrate:
         (1) The recommended settings for all adjustable relays, overcurrent protective devices and ground fault protective devices provided for the project.
         (2) The key or limiting overcurrent device characteristics, load characteristics, and protection requirements affecting the settings or ratings of the overcurrent protective devices supplied.
         (3) The degree of selective coordination achieved with the overcurrent protective devices supplied.
      b. Tabulation of the recommended settings for all adjustable relays, overcurrent protective devices and ground fault protective devices and type selections for fuse protective devices supplied.
      c. An analysis of the results in which any inadequacies related to selective coordination shall be called to the attention of the Engineer with recommendations for improved coordination.
   3. Arc Flash Hazard Analysis Study:
      a. The following for each piece of switchgear, switchboard, motor control center, distribution panel, panelboard, automatic transfer switch, enclosed circuit breaker, disconnect switch, and equipment control panel installed on the project:
         (1) Minimum Arc Fault Current, Arc Flash Boundary and Arc Fault Incident Energy Level (cal/cm2).
         (2) Risk of personnel injury as a result of exposure to incident energy released during an arc flash event.
         (3) Appropriate ratings of personal protective equipment (PPE).
         (4) The Flash Protection Boundary (approach limit distance).
         (5) Information for equipment specific arc-flash hazard warning labels.
      b. Recommendations and methods to mitigate the hazard risk, where applicable, in order to reduce PPE requirements.

4. Cut sheets and label specification information on the Arc Flash warning labels being provided.

1.06 QUALITY ASSURANCE:

A. The company and individual(s) performing the study shall have a minimum 5 years documented experience in power system analysis and completed projects of similar size and scope. The individual(s) performing the study shall be a registered Professional Engineer in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of Professional Engineer.
B. The company performing the study shall have the capability and experience to provide assistance during system start up.
C. Comply with IEEE 3002.3-2 for short-circuit currents and coordination time intervals.
D. Comply with IEEE 3001.5 for general study procedures.
E. Comply with IEEE 1584 or NFPA 70E for arc flash hazard analysis.

1.07 SEQUENCING AND SCHEDULING:

A. The selection of the company and the individual performing the study shall be submitted and approved by the design Engineer prior to the start of the study.
B. Preliminary short circuit analysis shall be completed prior to procurement of electrical equipment.
C. A meeting shall be conducted between Owner, Engineer and the Contractor to present the results of the preliminary short-circuit analysis and protective device coordination study results.
D. The study shall be completed and submitted and approved prior to the facility startup.

PART 2 - PRODUCTS

2.01 GENERAL:

A. The short circuit, protective device coordination, and flash hazard analysis study shall be completed with the aid of a computer software program such as ETAP.
B. The Contractor shall provide all lengths of cable for use in the studies.
C. All equipment ratings, make, and model information shall be obtained by the Contractor from the equipment manufacturers and/or suppliers and provided for use in the studies.
D. Information on the electrical service including available fault current, transformer impedance, primary fuse ratings, primary cable size, and any other required information shall be obtained from the local utility for inclusion in the studies.
E. The study shall be inclusive of the entire electrical distribution system from all power sources (normal and emergency) down to the branch circuit overcurrent protective device and equipment.
F. Separate calculations shall be performed for both the normal and emergency sources. Device settings shall be based upon the normal source study.
G. The Arc Flash Study shall be based on the study that results in the highest incident energy.

2.02 SHORT CIRCUIT COORDINATION STUDY:

A. The short circuit study shall as minimum include the following:
   1. A schematic one-line drawing of the entire electrical system included in the study, from the electrical utility source including the point of delivery, to each primary transformer, and including all main secondary buses of each transformer included in the study.

Secondary buses shall include multiple secondary transformations within the scope of the study. Each device shall be identified by the Engineer assigned equipment tag number indicated on the Contract Documents. Each motor greater than 1 hp shall be shown and identified. Each bus shall be identified by the Engineer assigned equipment tag number indicated on the Contract Documents.

2. Source voltage and impedance data shall be given in the analysis, including reactance and resistance in OHMS to the source, and available symmetrical and asymmetrical short circuit amperes at the point of delivery of electrical power. Short circuit amperes shall be based on an assumed bolted three-phase and line-to-ground short circuits.
3. At each bus, including buses of all primary protective and switching devices, primary and secondary of all transformers, all secondary main and feeder breakers, and all secondary devices and panelboards within the scope of the study, the following shall be calculated:
   a. Symmetrical RMS short circuit amperes, calculated using total source and motor contribution reactance and resistance values.
   b. Asymmetrical average 3 phase RMS amperes at 1/2 cycle, calculated using actual total source and motor contribution X/R ratio.
   c. Reactance ("X") and Resistance ("R") in OHMS at the voltage of the device being examined, including both electrical utility source and all motor contributions.
4. Calculation sheets for cable sections shall indicate voltage, wire size, cable length, reactance and resistance of the section in OHMS and total "X" and "R" to the source.
5. Calculation sheets for transformer sections shall indicate transformer kVA, secondary voltage, percent impedance, percent reactance, percent resistance, and total "X" and "R" value in OHMS at the secondary voltage to source, including the electrical utility source impedance plus any primary motor contribution.
6. Calculation sheets for busway and miscellaneous devices shall provide all pertinent parameters including operating voltage, section "X" and "R" values in OHMS, and total "X" and "R" values in OHMS to the source, based on source impedance plus any motor contribution.
7. Bus summary sheets shall be provided giving consecutive bus numbers, description, voltage, "X" and "R" values in OHMS including The electrical utility source plus all motor contributions, symmetrical and asymmetrical short circuit amperes, X/R ration, and asymmetrical factor.
8. Motor summary sheets shall provide motor description and all pertinent motor data including subtransient reactance for each motor greater than 1 hp. Symmetrical short circuit amperes shall be given for each motor at the motor terminals.

2.03 PROTECTIVE DEVICE COORDINATION STUDY:

A. The protective device coordination study shall as a minimum include the following:
   1. Time-current coordination plots shall be made on log-log software generated plots and shall graphically indicate the coordination proposed for all of the key systems. The plots shall include complete titles, one-line diagram and legend.
   2. The electrical utility source relay, fuse, or protective device shall be plotted with all load protective devices at the same voltage.
   3. Transformer primary protective device, transformer magnetic inrush, transformer ANSI withstand points, secondary voltage fuse or circuit breaker and largest feeder fuse or circuit breaker shall be plotted at the secondary voltage. Circuit breaker curves shall include complete operating bands, terminating with the appropriate available short circuit

current. Fuse curves shall be identified as either total clearing time or damage time as applicable.

4. Low voltage circuit breakers shall have instantaneous, short delay, long-time pick-up and ground fault trip settings and ground fault ampere and time delay settings identified as plotted. Sensor or monitor rating shall be stated for each circuit breaker. All regions of the circuit breaker curve shall be identified.
5. The coordination plots shall include significant motor starting characteristics and large motor protective devices.
6. Feeder circuit breakers shall have the time-damage curve of the feeder conductors plotted to indicate protection of the conductor insulation at the total clearing time of the circuit breaker or fuse. The time-damage point shall be calculated for the specific parameters of conductor insulation used, with average 3 phase RMS asymmetrical amperes as 1/2 cycle calculated using actual resistance and reactance values of the source plus all motor contributions which exist at the load end of the feeder conductors.
7. A determination of settings or ratings for the overcurrent and ground fault protective devices supplied. Where necessary, an appropriate compromise shall be made between selective coordination and service continuity with selective coordination considered more important than system service continuity.
8. A summary tabulation shall be provided listing manufacturer and type for all overcurrent protective devices and all recommended settings of each adjustable band included in each device.
9. Settings of protective devices shall minimize the arc flash hazard while maintaining selective coordination.

2.04 ARC FLASH HAZARD ANALYSIS STUDY:

A. The arc flash hazard analysis study shall as minimum include the following:
   1. Calculate incident energy levels and flash protection boundaries at all relevant equipment busses based on available short-circuit current, protective device clearing time, field data and other applicable one-line diagram information in accordance with IEEE - 1584.
   2. As a minimum, the following shall be calculated for each piece of switchgear, switchboard, motor control center, distribution panel, panelboard, automatic transfer switch, enclosed circuit breaker, disconnect switch, and equipment control panel to be installed on the project:
      a. Minimum Arc Fault Current, Arc Flash Boundary and Arc Fault Rating (cal/cm2).
      b. Risk of personnel injury as a result of exposure to incident energy released during an arc flash event.
      c. The appropriate ratings of personal protective equipment (PPE).
      d. The Flash Protection Boundary (approach limit distance) as required by NFPA 70E.
   3. Provide equipment specific arc-flash hazard warning label requirements per NFPA 70E, including all information specified to be provided on individual equipment warning labels.
   4. Provide recommendations and incorporate with the protective coordination study methods to mitigate the hazard risk, where applicable, in order to reduce PPE requirements.

B. Provide self-adhesive or plastic arc flash and available fault current labels for all electrical equipment in accordance with NFPA 70E.
   1. Self-adhesive or pressure-sensitive, preprinted, flexible vinyl signs for operational instructions or warnings; of sizes suitable for application areas and adequate for visibility.

PART 3 - EXECUTION

3.01 EXAMINATION:

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are as indicated on Drawings.

B. Proceed with coordination study only after relevant equipment submittals have been approved and assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

C. Prior to final electrical equipment selection Contractor shall review the short circuit study recommendations for the electrical Equipment ratings and provide Equipment that meets or exceeds those recommendations.

3.02 SETTINGS AND SELECTION:

A. Prior to project Substantial Completion, the Contractor shall:

1. Provide all current limiting fuses, and fused disconnects as required to for equipment to meet the short circuit ratings of the system.
2. Set all relays, overcurrent devices and ground fault protection devices:
    a. Relays: Reset all adjustable relay settings from the factory default settings to the settings recommended in the studies specified in this SECTION.
    b. Circuit Breakers and Motor Circuit Protectors: Reset all adjustable trip settings from the factory default settings to the settings recommended in the studies specified in this SECTION.
    c. Ground Fault Protection Devices: Reset all adjustable device settings from the factory default settings to the settings recommended in the studies specified in this SECTION.
3. Replace all fuses that do not meet the recommendations of the studies specified in this SECTION with fuses that are recommended.

B. Certification: Prior to project Substantial Completion, the Contractor shall submit a document certifying that the Contractor has completed the settings and selection scope specified to the Engineer.

3.03 INSTALLATION:

A. Provide Arc Flash Warning signs on electrical equipment such as switchboards, switchgear, panelboards, industrial control panels, motor control centers and meter socket enclosures that are likely to require examination, adjustment, servicing, or maintenance while energized. Marking shall be permanently affixed and of a durable nature to withstand the environment within which it is installed.

END OF SECTION 26 05 73

SECTION 26 22 13 – LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this SECTION.

1.02 SUMMARY:

A. This SECTION specifies transformer work as indicated by Drawings and Schedules.
B. Types of transformers specified in this SECTION include the following:
   1. Dry-type transformers.

1.03 RELATED REQUIREMENTS:

A. SECTION 26 00 00 - General Electrical Requirements
B. SECTION 26 05 26 - Grounding and Bonding for Electrical Systems
C. SECTION 26 05 53 - Identification for Electrical Systems
D. SECTION 26 05 73 - Short-Circuit, Coordination and Arc-Flash Hazard Analysis Studies.

1.04 REFERENCE STANDARDS:

A. ASTM International (ASTM):
   1. ASTM D877/D877M – Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids using Disk Electrodes.
   2. ASTM D923 - Standard Practice for Sampling Electrical Insulating Liquids.
B. Code of Federal Regulations (CFR):
   1. 10 CRF Part 429 - Certification, Compliance, and Enforcement for Consumer Products and Commercial and Industrial Equipment.
      a. 429.47 - Distribution Transformers.
   2. 10 CFR Part 431 - Energy Efficiency Program For Certain Commercial and Industrial Equipment, Subpart K – Distribution Transformers.
      a. 431.193 - Test procedures for measuring energy consumption of distribution transformers.
      b. 431.196 - Energy Conservation Standards.
C. Institute of Electrical and Electronics Engineers (IEEE):
   1. IEEE C2 - National Electric Safety Code.
   2. IEEE C57.12.00 - General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.
   3. IEEE C57.12.01 - General Requirements for Dry-Type Distribution and Power Transformers.
   4. IEEE C57.12.25 - Transformers Pad-Mounted, Compartmental-Type, Self-Cooled, Single-Phase Distribution Transformers with Separable Insulated High-Voltage Connectors; High Voltage, 34,500 GrdY/19,920 Volts and Below; Low Voltage, 240/120 Volts; 167 kVA and Smaller Requirements.
   5. IEEE C57.12.50 - Requirements for Ventilated Dry-Type Distribution Transformers 1 to 500 kVA, Single-Phase, and 15 to 500 kVA, Three-Phase with High-Voltage 601 to 34,500V, Low Voltage 120-600V.
   6. IEEE C57.12.90 - Test Code for Liquid-Immersed, Distribution, Power, and Regulating Transformers.
   7. IEEE C57.12.91 - Test Code for Dry-Type Distribution and Power Transformers.

D. National Electrical Manufacturers Association (NEMA):
   1. NEMA ST 20 - Dry-type Transformers for General Applications.
   2. NEMA TR 1 - Transformers, Regulators, and Reactors. (Supplements IEEE C57 - Series Standards.)
   3. NEMA 250 - Enclosures for Electrical Equipment.

E. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code (NEC). Comply with NEC as applicable to installation and construction of electrical power/distribution transformers.

F. Underwriters Laboratories (UL):
   1. Comply with applicable requirements of UL 506 Safety Standard for Specialty Transformers. Provide transformers and components which are UL-listed and labeled.
   2. UL 1561 - Large General Purpose Transformers.

1.05 SUBMITTALS:

A. In addition to the requirements of SECTION 01 33 00, submittals shall also include, but not be limited to, the following:
   1. Product Data: Submit for each type of product specified and included, with the following as a minimum:
      a. Technical product data: Includes, but not limited to, rated kVA, frequency, primary and secondary voltages, wiring diagram, percent taps, polarity, impedance and certification of transformer performance efficiency at 100% load, percentage voltage regulation at 100% load at 75ºC, full-load losses in watts, percent impedance at 75ºC, hot-spot and average temperature rise above 40ºC ambient temperature, sound level in decibels, and standard published data.
   2. Shop Drawings: Submit the following as a minimum:
      a. Manufacturer's drawings indicating dimensions and weight loadings for transformers and wall brackets.
      b. Transformer nameplate data.
      c. Wiring Diagrams: Submit wiring and control diagrams for transformers. Clearly differentiate between portions of wiring that are manufacturer factory installed and portions to be field-installed.
   3. Submit all field test data.
   4. Closeout Submittals: Final documentation shall include:
      a. Operation and Maintenance manuals.
      b. Certified “As-Built” drawings.
      c. Copies of all approved Product Data.
      d. Copies of all approved Test Reports.
      e. Warranty information.

1.06 QUALITY ASSURANCE:

A. As specified in SECTION 01 40 00.

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

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in PART 3.

C. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.

D. Source Limitations: Obtain each transformer type through one source from a single manufacturer.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

F. Comply with IEEE C2, National Electric Safety Code.

G. Comply with IEEE C57.12.90, Test Code for Liquid-Immersed, Distribution, Power, and Regulating Transformers. or IEEE C57.12.91, Test Code for Dry-Type Distribution and Power Transformers.

H. Testing procedures shall comply with 10 CFR 429.47 - Distribution Transformers and 10 CFR 431.193 - Test procedures for measuring energy consumption of distribution transformers.

1.07 DELIVERY, STORAGE, AND HANDLING:

A. As specified in SECTION 01 60 00.

B. Transformers shall be stored according to the manufacturer’s instructions and in a conditioned space to avoid condensation, dust, and other environmental contaminants.

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

D. Handle and prepare transformers for installation according to NEMA ST 20 and manufacturer’s instructions.

1.08 PROJECT SITE CONDITIONS:

A. Environmental Limitations:

1. Do not deliver or install transformers until spaces are enclosed and weather tight, any wet work is complete and dry, work above transformers is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

B. Service Conditions: NEMA ST 20, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 3,300 feet.

1.09 WARRANTY:

A. The warranty shall comply with the requirements of SECTION 01 78 36.

1.10 COORDINATION:

A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

A. Subject to compliance with requirements, provide products of one of the following (for each type of transformer):

1. Eaton.
2. General Electric Company.
3. Sola/Hevi-Duty, Emerson Electric Co.
4. Siemens.
5. Square D, Schneider Electric.

2.02 TRANSFORMERS:

A. General:

1. Except as otherwise specified or indicated, provide manufacturer's standard materials and components as indicated by published product information, designed and constructed as recommended by manufacturer, and as required for complete installation.
2. Comply with DOE energy efficiency standards as defined by 10 CFR Part 431.196 – Energy Conservation Standards for all transformers 15 kVA and larger.
3. Core material shall be grain-oriented, non-aging silicon steel. Coils shall be continuous windings without splices except for taps. Internal coil connections shall be brazed or pressure type.
4. Enclosure ratings shall comply with NEMA 250 – Enclosures for Electrical Equipment.

B. Dry-Type Transformers (45 kVA or less):

1. Factory-assembled and tested, general-purpose, air-cooled, dry-type transformers; of sizes, characteristics, and rated capacities indicated.
2. Three-phase transformer: 480V delta connected primary and 208/120V wye-connected secondary with grounded neutral, 60-hertz, 10 kV BIL.
3. Single-phase transformer: 480V primary to a 120/240V center-tapped secondary, with grounded neutral, 60-hertz, 10 kV BIL.
4. Copper primary and secondary windings. Manufacturer’s standard impedance.
5. Provide primary winding with 4 full-capacity taps; two 2-1/2% increments below and above full-rated voltage for de-energized tap-changing operation.
6. Insulate with 220ºC, UL-component-recognized insulation system with a maximum of 115ºC rise above 40ºC ambient temperature.
7. Rate transformer for continuous operation at rated kVA.
8. Limit transformer surface temperature rise to maximum of 65ºC.
9. Provide terminal enclosure, with cover, to accommodate primary and secondary winding connections and raceway connectors.

10. Equip terminal leads with connectors installed. Limit terminal compartment temperature to 75ºC when transformer is operating continuously at rated load with ambient temperature of 40ºC. Provide wiring connectors suitable for copper wiring.
11. Cushion-mount transformers with external vibration isolation supports.
12. Sound-level ratings shall not exceed IEEE/NEMA standards. Conform to NEMA ST 20.
13. Electrically ground core and coils to transformer enclosure by means of flexible metal grounding strap.
14. Provide transformers with ventilated or fully enclosed sheet steel enclosures. Apply manufacturer's standard light gray indoor enamel over cleaned and phosphatized steel enclosure.
15. All transformers shall be suitable for floor mounting unless noted otherwise.
16. Provide wall mounting brackets for wall- or column-mounted transformers.
17. Must comply with IEEE C57.12.01 and/or IEEE C57.12.50.
18. Must comply with UL 1561.

C. Final equipment selection: Review the short circuit equipment study. Provide only equipment that meets or exceeds the recommendation of that short circuit study specified in SECTION 26 05 73.

D. Equipment/System Identification: Provide equipment/system identification nameplates complying with SECTION 26 05 53.

E. Finishes: Coat interior and exterior surfaces of transformer, including bolted joints, with manufacturer's standard color baked-on enamel.

PART 3 - EXECUTION

3.01 EXAMINATION:

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in SECTION 26 05 26. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION:

A. Install transformers as indicated, complying with manufacturer's written instructions, applicable requirements of NEC, NESC, NEMA, and IEEE standards in accordance with recognized industry practices to ensure that products fulfill requirements. Arrange equipment to provide adequate space for access and for cooling air circulation.

B. Tighten electrical connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torqueing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A.

C. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer. Wall brackets shall meet the environmental requirements of the transformer installation for each location.

1. Brace wall-mounting transformers.

D. Construct concrete bases and anchor floor-mounted transformers according to manufacturer's written instructions.

3.03 CONNECTIONS:

A. Provide equipment grounding connections for transformers as specified, indicated, and as required. Tighten connections to comply with tightening torques specified in UL 486A to assure permanent and effective grounding. Provide grounding in accordance with SECTION 26 05 26.

3.04 IDENTIFICATION:

A. Provide all warning signs, nameplates, labels and markers as specified in SECTION 26 05 53.
B. Label field-installed conductors, interconnecting wiring, and components.
C. Provide Equipment and conduit warning signs.
D. Provide Equipment nameplates.
E. Place arc flash label on equipment.

3.05 FIELD QUALITY CONTROL:

A. Tests and Inspections:
   1. Prior to energization of transformers, check all accessible connections for compliance with manufacturer's torque tightening specifications. Clean out any dust and dirt.
   2. Prior to energization, check circuitry for electrical continuity and for short circuits.
   3. Perform insulation resistance test: Megger between high-voltage winding to low-voltage winding, low-voltage winding to ground, and high-voltage winding to ground. Record and submit test results. If readings are below 50 megohms (at 77°F), notify Engineer before energizing transformer.
   4. Perform transformer turns ratio test (TTR) on the full winding and all taps. Record and submit test results.
   5. On liquid-filled transformers, perform insulating liquid dielectric test in accordance with ASTM D923 and ASTM D877.
   6. Check cooling fans and controls, where provided, for proper operation.
   7. Upon completion of installation of transformers and testing, energize primary circuitry at rated voltage and frequency from normal power source, and test transformers, including, but not limited to, audible sound levels, to demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at the Site then retest to demonstrate compliance; otherwise, remove and replace with new units or components and proceed with retesting.
   8. Adjust transformer primary taps for nominal system voltage at initial installation and again when the transformer reaches its designed "full" load condition after occupancy by the Owner. Schedule all required electrical outages with the Owner.

B. Harmonic Profile Tests for K-Rated Transformers:
   1. Three months after building occupancy by the Owner, the Contractor shall field measure and record the following data during normal week-day (Monday-Friday) hours for each 208V secondary of each K-rated transformer:
      a. Transformer Number.
      b. Circuit Number.
      c. Date and Time.

d. Volts: ØA-ØB, ØB-ØC, ØC-ØA, ØA-N, ØB-N, ØC-N, N-G.
e. Amperes: ØA, ØB, ØC, N.
f. Fluke Model Number 41 Power Harmonics Meter data for amperes and volts of each of three phases:
   (1) 60-hertz true rms reading.
   (2) 60 hertz as percent of total.
   (3) Third harmonic as percent of total.
   (4) Fifth harmonic as percent of total.
   (5) Seventh harmonic as percent of total.
   (6) Ninth harmonic as percent of total.
   (7) Eleventh harmonic as percent of total.
   (8) Thirteenth harmonic as percent of total.
   (9) Fifteenth harmonic as percent of total.
   (10) Amperes Dc.
   (11) Percent Total Harmonic Distortion.
   (12) Crest Factor.
   (13) K-Factor.
   (14) Power Factor.

3.06 FINISHES:

A. Equipment coatings shall be free from scratches, rust, or other defects.
B. All damaged or defective coatings shall be repaired prior to final acceptance.
C. Field Painting:
   1. Touch Up:
      a. Contractor shall prepare surfaces and touch up manufacturer applied coatings as required for any damage during shipment and installation.
      b. Field painting shall be performed based on manufacturer's recommended procedures.
      c. Transformer manufacturer shall furnish Contractor with an adequate quantity of touch-up paint to match the factory applied finish.

3.07 ADJUSTING AND CLEANING:

A. Upon completion of installation, clean interior and exterior of transformers. Remove paint splatters, spots, dirt and debris.

3.08 PROTECTION:

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until unit is placed into service.

END OF SECTION 26 22 13

SECTION 26 24 16 - PANELBOARDS

1.01 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY:

A. This Section specifies panelboards and mini-power centers, including cabinets and boxes, as indicated by Drawings and Schedules, and as specified herein.

B. Types of panelboards and enclosures required for the Project include the following:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.
3. Mini-power centers.

1.03 RELATED REQUIREMENTS:

A. SECTION 26 00 00 - General Electrical Requirements
B. SECTION 26 05 26 - Grounding and Bonding for Electrical Systems
C. SECTION 26 05 53 - Identification for Electrical Systems
D. SECTION 26 05 73 - Short-Circuit, Coordination and Arc-Flash Hazard Analysis Studies
E. SECTION 26 43 13 - Surge Protective Devices for Low-Voltage Electrical Power Circuits

1.04 REFERENCE STANDARDS:

A. Publication Dates: Comply with the latest standards revision in effect as of the date of the Contract Documents unless otherwise indicated.

B. Code of Federal Regulations (CFR):

1. 10 CRF Part 429 – Certification, Compliance, and Enforcement for Consumer Products and Commercial and Industrial Equipment.
    a. 429.47 – Distribution Transformers.
2. 10 CFR Part 431 – Energy Efficiency program For Certain Commercial and Industrial Equipment, Subpart K – Distribution Transformers.
    a. 431.193 – Test procedures for measuring energy consumption of distribution transformers.
    b. 431.196 – Energy Conservation Standards.

C. Institute of Electrical and Electronic Engineers (IEEE):

1. IEEE C62.41.1 – Surge Environment in Low-Voltage (1000V and less) AC Power Circuits.
2. IEEE C62.41.2 – Characterization of Surges in Low-Voltage (1000V and less) AC Power Circuits.
3. IEEE C62.45 – Surge Testing on Equipment Connected to Low Voltage (1000V and less) AC Power Circuits.
4. IEEE C62.62 – Test Specification for Surge Protective Devices for Low Voltage AC Power Circuitry.

D. National Electrical Manufacturers Association (NEMA):

1. NEMA 250 – Enclosures for Electrical Equipment (1,000V Maximum).
2. NEMA PB 1 – Panelboards.
3. NEMA PB 1.1 – General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600V or Less.
4. NEMA PB 2.2 – Application Guide for Ground-Fault Protective Devices for Equipment.
5. NEMA ST 20 – Dry Type Transformers for General Applications.

E. National Fire Protection Association (NFPA):

1. NFPA 70 - National Electrical Code (NEC): Comply with applicable local code requirements of the authority having jurisdiction and NEC as applicable to installation and construction of electrical panelboards and enclosures.

F. Underwriters Laboratories (UL): Provide panelboard units which are UL listed and labeled.
1. UL 50 - Electrical Cabinets and Boxes.
2. UL 67 - Electrical Panelboards.
3. UL 486A - Wire Connectors and Soldering Lugs for Use with Copper Conductors.
4. UL 489 - Molded-Case Circuit Breakers and Circuit Breaker Enclosures.
5. UL 869A - Electrical Service Equipment.
6. UL 1053 - Ground-Fault Sensing and Relaying Equipment.
7. 1283 – Electromagnetic Interference Filters.
8. 1449 – Safety for Surge Protective Devices.
9. Special Use Markings: Provide panelboards constructed for special use with appropriate UL markings which indicate that they are "Suitable for Use as Service Equipment" where applicable.

G. Federal Specification (FS) Compliance: Comply with applicable requirements of the following standards.
1. FS W-C-375 Series – Molded-Case Circuit-Breakers, Branch Service and Circuit.
2. FS W-P-115C – Panel, Power Distribution.
3. FS W-C-375 – Circuit Breakers, Molded Case; Branch Circuit and Service.

1.05 SUBMITTALS:

A. Submittals shall be custom prepared by the panelboard manufacturer for this specific application.

B. In addition to the requirements of SECTION 01 33 00, submittals shall also include, but not be limited to, the following:
1. Product Data: Submit for each type of product specified and included, with the following as a minimum:
a. Data sheets for all components furnished as part of the system package.
2. Shop Drawings: Provide the following as a minimum:
a. Panelboard dimensions and weight.
b. Complete data on circuit breakers.
c. Panelboard short-circuit interrupting capacity, and information on buses: Phase, neutral, and ground.
d. Information on whether panelboard is fed from top or bottom.
e. Data on maximum and minimum incoming and outgoing feeder and branch circuit wire size.
f. Data on door, locks, and mounting: Surface or flush.
g. Data on total number of poles and number of unused poles that is available for future use.
3. Closeout Submittals: Final documentation shall include the following as minimum:
a. Operation and Maintenance Manuals including the following:
(1) Operation and maintenance manuals for all components furnished.
(2) Certified “As-Built” drawings of all equipment with information listed above.
(3) Copies of all approved Product Data.
(4) Copies of all approved Test Reports.
(5) Warranty Information.

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

1.06 QUALITY ASSURANCE:

A. Materials and Equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of such products and shall be the manufacturer's latest standard design that has been in satisfactory use for at least one year prior to Bid opening.
B. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
D. Panelboards shall comply with NEMA PB 1.
E. Comply with NFPA 70.
F. Mini-power centers shall conform to the applicable requirements of 10 CFR 429.47 – Distribution Transformers and 10 CFR 431.193 – Test procedures for measuring energy consumption of distribution transformers.

1.07 DELIVERY, STORAGE, AND HANDLING:

A. Panelboards shall be stored according to the manufacturer's instructions and in a conditioned space to avoid condensation, dust, and other environmental contaminants.
B. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (Approximately 250 watts per panelboard for average conditions) to prevent condensation.
C. Handle and prepare panelboards for installation according to NEMA PB 1 and manufacturer's instructions.

1.08 PROJECT SITE CONDITIONS:

A. Environmental Limitations:
    1. Do not deliver or install panelboards until spaces are enclosed, weathertight, dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
    2. Service Conditions: Rate equipment for continuous operation under the following conditions unless otherwise indicated.
        a. Ambient Temperature Limits: -5ºC through 40ºC.
        b. Altitude not exceeding 6,600 feet.
B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
    1. Notify Owner no fewer than two days in advance of proposed interruption of electric service.
    2. Do not proceed with interruption of electric service without Owner's written permission.

1.09 COORDINATION:

A. Coordinate the layout and installation of panelboards and components with other types of equipment including raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.10 WARRANTY:

A. All equipment furnished under this Section shall be warranted by the Contractor and the equipment manufacturer(s) for a minimum period of one year after substantial completion.

B. Warranty shall include all parts, labor, and expenses to perform necessary work.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

A. Subject to compliance with requirements, provide panelboard and mini-power center products of one of the following (for each type and rating of panelboard and enclosure):
   1. Eaton.
   2. General Electric Company, ABB.
   3. Siemens.
   4. Square D, Schneider Electric.

2.02 GENERAL REQUIREMENTS FOR PANELBOARDS:

A. Except as otherwise indicated, provide panelboards, enclosures, and ancillary components of types, size, and ratings indicated, which comply with manufacturer's standard materials and with the design and construction in accordance with published product information.

B. Where types, sizes, or ratings are not indicated, comply with NEC, UL, and established industry standards for those applications indicated.

C. Equip with proper number of panelboard switching and protective devices as required for complete installation.

D. Provide ground fault circuit interrupter type circuit breakers where indicated.

E. Enclosures: Flush- and surface-mounted cabinets as indicated.
   1. Provide enclosures fabricated by same manufacturer as panelboards which mate and match properly with panelboards.
   2. Rated for environmental conditions at installed location. Provide NEMA type as described below and as defined by NEMA 250, unless indicated or specified otherwise.
      a. Indoor Dry and Clean Locations: NEMA Type 1.
      b. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA Type 12.
      c. Outdoor Locations: NEMA, Type 4X stainless steel.
      d. Wash-Down Areas: NEMA, Type 4X stainless steel.
      e. Other Wet or Damp Indoor Locations: NEMA Type 4X.
   3. Materials: Galvanized sheet steel cabinet type enclosures, in sizes required. Provide code gage (minimum 16-gage) thickness steel.
   4. Must be UL 50 listed.

5. Front: Secured to box with adjustable, concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
6. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Front doors shall have flush locks with three keys per panelboard, all panelboard enclosures keyed alike.
7. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
8. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections. Provide multiple knockouts and wiring gutters. Provide hinged doors over vertical wiring gutter.
9. Finishes:
    a. Color: Baked gray enamel finish over a rust inhibitor coating.
    b. Panels and Trim: Galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
    c. Back Boxes: Galvanized steel. Stainless Steel for NEMA 4X panelboards
10. Directory Card: Inside panelboard door, equip with interior circuit directory frame and removable card with clear plastic covering.

F. Phase, Neutral, and Ground Buses:
1. Bus shall be braced to withstand available short-circuit currents as indicated.
2. Provide suitable lugs on neutral bus for incoming and outgoing feeders requiring neutral connections.
3. Equipment Ground Bus: Bare, uninsulated, adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Material: Tin-plated aluminum.
5. Material: Tin-plated aluminum.
6. Main and Neutral Lugs: Mechanical type.
7. Ground Lugs and Bus-Configured Terminators.
8. All lugs shall be mechanical type.
9. Provide terminals UL rated for 75ºC (minimum) conductors.

G. Service Equipment Label: NRTL labeled for use as service equipment for panelboards with one or more main service disconnecting and overcurrent protective devices.

H. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

I. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals as indicated.

J. Final equipment selection: Review the short circuit equipment study. Provide only equipment that meets or exceeds the recommendation of that short circuit study specified in SECTION 26 05 73.

K. Surge Protection Devices: Provide an integral surge protection device for each panelboard as specified. Refer to Section 26 43 13 – Surge Protection Devices for Low-Voltage Electrical Power Equipment for device requirements.

L. Provide panelboard nameplate as indicated.

M. Mini-power centers shall be provided with integral primary and secondary protection. Provide a primary circuit breaker upstream of the integral transformer and a secondary circuit breaker upstream of the panelboard section of the mini-power center.

N. Size feeder conductors and cables fed from the panelboard per NEC requirements.

2.03 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS:

A. Panelboards: NEMA PB 1, dead front, safety type, 480Y/277V and 208Y/120V (voltage rating as required), 3 phase, 4 wire, 120/240V, single phase, 3 wire, 60 hertz with full-sized neutral bus.
B. Lighting and appliance branch-circuit type as indicated with switching and protective devices in quantities, ratings, types, and arrangements shown.
C. Incoming Mains Location: Top or bottom as required.
D. Mains: Circuit breaker or lugs only as indicated.
E. Branch Overcurrent Protective Devices:
    1. Bolt-on, molded-case circuit breakers.
    2. Molded-case circuit breakers shall have toggle handles that indicate when tripped.
    3. Where multiple pole breakers are indicated, provide with common trip so overload on one pole will trip all poles simultaneously.
    4. Circuit breakers shall be replaceable without disturbing adjacent units.
F. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.
G. Provide spare 20A and 30A single pole breakers for all unused space within the panelboard
H. Provide an integral surge protection device to protect the panelboard as specified in SECTION 26 43 13.

2.04 PANELBOARD INTEGRAL SURGE PROTECTION DEVICE:

A. Provide surge protection device (SPD) designed for installation within the panelboard. The SPD shall connect directly to the bus bar and have an integral disconnect. SPD shall be approved by panelboard manufacturer for installation within the panelboard. Indicating lights shall be mounted in the face of the panelboard. The unit shall provide the following modes of protection: line-to-line (L-L), line-to-ground (L-G), line-to-neutral (L-N), and neutral to ground (N-G).
B. Provide SPD as specified in SECTION 26 43 13.
C. SPDs shall have the following characteristics:
    1. UL 1449 Fourth Edition listed and labeled.
    2. The surge environment and surge characteristics for the SPD shall be as defined by IEEE C62.41.1 and IEEE C62.41.2.
    3. Shall be of a parallel design using fast-acting transient energy protection that will divert and dissipate the surge energy.
    4. Shall use metal oxide varistor technology. (Spark gaps, gas tubes, selenium cells and SCRs shall not be acceptable.)
    5. Shall include internal fuses and thermally protection over every suppression component of every mode, including N-G for wye configurations.
    6. Shall be factory-installed by the panelboard manufacturer via a direct bus bar connection immediately following the load side of the main breaker. SPDs installed in main lug only panelboards shall be installed immediately following the incoming main lugs.
    7. The panelboard shall be capable of re-energizing upon removal of the SPD.
    8. Shall have integral, panel-front status monitors or remote status panel ability as a minimum to indicate a continuous positive status of all protected modes. Diagnostics shall be electrically isolated to prevent damage by surges.
    9. The maximum continuous operating voltage at 60 Hz shall be capable of sustaining at least 115% of the peak voltages continuously without degrading.

10. The maximum UL 1449 Third Edition Voltage Protection Ratings (VPR) for the device must not exceed the following:

Service	L-N	L-G	N-G	L-L	MCOV
120/240Vac, 3-Wire + Gnd	700V	700V	700V	1200V	150V
208/120Vac, 3-phase, 4-wire	700V	700V	700V	1200V	150/276V
480 Vac 3-phase, 3-wire Delta	NA	1800V	NA	1800V	550V
480/277 Vac, 3-phase, 4-wire	1200V	1200V	1200V	2000V	550/320V

11. Shall be UL labeled with 20kA I-n for compliance to UL 96A Lightning Protection Master Label and NFPA 780.
12. Shall be UL labeled as a Type 1 or Type 2 device and shall not require external or supplemental overcurrent safety controls to meet UL 1449 3rd Edition.
13. Warranty: SPD manufacturer shall provide free replacement of the entire model with a minimum warranty period of 10 years from date of shipment. This warranty shall be limited only by failure to comply with manufacturer's installation instructions and applicable national or local code and may not exclude lightning or temporary overvoltage (TOV).

D. Accessories:
   1. Green LED status indicator per phase.
   2. Red LED service indicator.
   3. Test function for LEDs and audible alarm.
   4. Internal audible alarm with mute switch.
   5. Surge event counter.

PART 3 - EXECUTION

3.01 EXAMINATION:

A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.
B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
C. Verify Site conditions are suitable for installation of equipment.
D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the work.
E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION OF PANELBOARDS:

A. Install panelboards, mini-power centers, and enclosures as indicated, providing NEC required working space, in accordance with manufacturer's written instructions, applicable requirements of NEC and in compliance with recognized industry practices to ensure that products fulfill requirements.

B. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torqueing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A.

C. Fasten enclosures firmly to walls and structural surfaces, ensuring that they are permanently and mechanically anchored.

D. Provide properly wired electrical connections for panelboards within enclosures.

E. Install numbers on all circuit breakers and type the panelboard's circuit directory card upon completion of installation work. Clearly identify the load on each circuit and the circuit number according to the Contract Drawings.

F. Provide filler plates in all unused spaces.

G. Provision for future circuits at all flush mounted panelboards (unless indicated otherwise): Extend four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Extend four 1-inch conduits into raised floor space or below floor slab (not required for slabs on grade or basement floor slabs).

3.03 GROUNDING:

A. Provide equipment grounding connections for panelboard enclosures as indicated and as required by NEC. Tighten connections to comply with tightening torques specified in UL 486A to assure permanent and effective grounds. Provide grounding as specified in SECTION 26 05 26.

3.04 IDENTIFICATION:

A. Provide all warning signs, nameplates, labels and markers as specified in SECTION 26 05 53.

B. Label field-installed conductors, interconnecting wiring, and components;

C. Provide Equipment and conduit warning signs.

D. Provide Equipment nameplates.

E. Create a directory to indicate installed circuit loads; incorporate equipment served and room designations as indicated on the Drawings. Use a computer printer to create directory; handwritten directories are not acceptable. Directory shall be subject to approval by the Engineer and Owner.

3.05 FIELD QUALITY CONTROL:

A. Perform tests and inspections as specified and as recommended by the equipment manufacturer.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections as specified and as recommended by the equipment manufacturer.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Acceptance Testing Preparation:
   1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

E. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   3. Prior to energization of electrical circuitry, check all accessible connections to manufacturer's tightening torque specifications.
   4. Prior to energization, check panelboard circuits for short circuits, electrical continuity of circuits, enclosure grounding and neutral grounding at service entrance and at incoming derived source transformer.
   5. Prior to energization of panelboards, check with insulation resistance tester the phase-to-phase and phase-to-ground insulation resistance levels of each phase bus to ensure requirements are fulfilled. Record and submit test results.
   6. Panelboards will be considered defective if they do not pass tests and inspections.
   7. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.06 FINISHES:

A. Equipment coatings shall be free from scratches, rust, or other defects.
B. All damaged or defective coatings shall be repaired prior to final acceptance.
C. Field Painting:
   1. Touch Up:
      a. Contractor shall prepare surfaces and touch up manufacturer applied coatings as required for any damage during shipment and installation.
      b. Field painting shall be performed based on manufacturer’s recommended procedures.
      c. Panelboard manufacturer shall furnish Contractor with an adequate quantity of touch-up paint to match the factory applied finish.

3.07 ADJUSTING AND CLEANING:

A. Adjust moving parts and operable components to ensure normal function as recommended by manufacturer.
B. Upon completion of installation, clean interior and exterior of panelboards. Remove paint splatters, spots, dirt and debris.
C. Touch-up scratched or marred surfaces to match original finishes.
D. Adjust transformer taps of mini-power centers as required.

3.08 PROTECTION:

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

3.09 DEMONSTRATION:

A. Subsequent to final wire and cable hook-ups, energize panelboards and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance.

END OF SECTION 26 24 16

SECTION 26 33 53 – STATIC UNINTERRUPTIBLE POWER SUPPLY

GENERAL

1.01 SUMMARY:

A. This Section specifies Uninterruptible Power Supply (UPS) systems and associated accessories.

B. Provide UPS units and accessories as specified.

1.02 RELATED REQUIREMENTS:

A. Section 40 66 00 - Network and Communication Equipment.

B. Section 40 67 00 - Process Control Panels and Hardware.

1.03 REFERENCE STANDARDS:

A. Publication Dates: Comply with standards in effect as of date of the Contract Documents.

B. The seller shall furnish Equipment which conforms in all respects to applicable industry standards and sound engineering practice.

C. Design, fabricate, assemble, install and test Equipment to conform to the applicable standards specified herein.

D. National Fire Protection Association (NFPA):

1. NFPA 70 – National Electrical Code.

E. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE C62.41 – Surge Voltages in Low-Voltage AC Power Circuits.
2. IEEE C62.41.1 – Surge Environment in Low-Voltage (1000 Volts and less) AC Power Circuits.
3. IEEE C62.41.2 – Characterization of Surges in Low-Voltage (1000 Volts and less) AC Power Circuits.
4. IEEE 519 – Harmonic Control in Electric Power Systems.
5. IEEE 944 – Recommended Practice for the Application and Testing of Uninterruptible Power Supplies for Power Generating Stations.

F. Code of Federal Regulations (CFR), Federal Communications Commission (FCC):

1. 47 CFR - FCC Part 15, Subpart J, Class A.

G. Underwriters Laboratories (UL).

1. UL 1449 – Surge Protective Devices.
2. UL 1778 – Uninterruptible Power Supply Equipment.

H. British Standards Institute

1. BS EN 50160 - Voltage characteristics of electricity supplied by public electricity networks.

1.04 SUBMITTALS:

A. In addition to the requirements of SECTION 01 33 00, submittals shall include the following:

B. Product Data:

1. Device list and bills of material.
2. Specification data sheets for all hardware and software.

1.05 QUALITY ASSURANCE:

A. All Equipment and Material furnished shall have an acceptable history of satisfactory reliable service in similar use for a period of at least two years.

B. Equivalent newly developed Equipment with less than two years actual service will be considered from established manufacturers if it has been adequately tested, meets the

requirements of this Contract, and is approved by Contractor. Such Equipment shall be noted in the proposal for review.

C. Factory Tests:
   1. Perform factory tests on complete system to verify proper operation before delivery to jobsite.

1.06 SITE CONDITIONS:

A. All Equipment provided as part of this system shall be rated for the temperature, seismic and elevations as specified in the Site Conditions in SECTION 26 00 00.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

A. Uninterruptible Power System (UPS):
   1. American Power Conversion (APC), Schneider Electric.
   2. Eaton.
   3. Liebert, Emerson Electric Company.

2.02 SCALABLE, DOUBLE CONVERSION UPS:

A. Scalable, network grade, on-line double conversion, uninterruptible power system with continuous line conditioning, inverter, batteries and control system.
B. N+1 redundancy with one more power module than is required to support rated load.
C. Field replaceable, hot swappable power and battery modules.
D. Redundant and hot swappable control modules.
E. Internal bypass.
F. Tower unit with minimum chassis capacity to support full unit rating and provide minimum runtime specified.
G. Electrical Capacity: Provide scalable unit with installed capacity and full unit rating as specified. Scalable increments shall be a maximum of 4kVA.
H. Provide a unit that will produce its full rated output continuously.
I. The unit shall utilize double conversion technology to continuously clean the power in either normal or emergency mode to protect against spikes, sags, surges, noise, lightning, and brownouts.
J. Input Voltage: 120 volt, 60 hertz, single phase (2-wire with ground).
K. Output Voltage: 120 volt, 60 hertz, single phase (2-wire with ground).
L. The unit shall automatically switch to battery inverter backup upon loss of power and retransfer on return of normal power. These transfers shall have no effect on the output waveform and shall be transparent to the connected load.
M. The output waveform will be 60 hertz ±0.5-hertz sine wave with less than 5% total harmonic distortion (THD).
N. Shall conform to IEEE 519.
O. Surge withstand shall exceed C62.41.1 and C62.41.2.
P. Noise rejection - common mode better than 120 dB; transverse mode greater than 60 dB.
Q. Output shall have an isolated neutral.
R. Electromagnetic interference shall be minimized to ensure that computer systems shall neither effect nor be affected by the UPS. RFI filtering shall be provided on the input and output to minimize high frequency noise interference.
S. The batteries shall be sealed maintenance-free type.
T. The battery charger shall be fully automatic capable of recharging the batteries within 3 hours.

U. The unit shall automatically disconnect from the batteries and shutdown, preventing damage to the batteries due to a deep discharge.
V. The battery capacity shall be such to be able to sustain a power outage of 30 minutes at 100% rated wattage output, and to maintain 50% of rated wattage output for a period of 60 minutes.
W. Ambient Environment: 0°C to 40°C.
X. Provide with an LCD operator interface. Status indicators and audible alarm shall indicate normal, transfer to inverter, battery charging and overload, or failure alarm.
Y. Provide with UPS management card with dry contact (relay) support to monitor external triggers and initiate actions on external devices. Input and output functions shall be configurable through DIP switches or software configuration. Contacts shall be rated for a minimum of 5A at 120Vac.
Z. Maintenance Bypass Switch:
    1. Provide a maintenance bypass switch for the supplied UPS.
    2. Bypass switch shall allow line and UPS inputs/outputs to be made using NEMA 5-15P cord and plug connections.
    3. Transfer to and from maintenance bypass shall not interrupt the connected load.
    4. Transfer time shall be less than 6 milliseconds.
    5. Provide Liebert MicroPOD series, APC Service Bypass Panel, or Contractor approved equal.
AA. The UPS shall conform to UL 1778. When the UPS is installed within UL508A listed control panels the control panel environment shall be maintained to UL 1778 requirements.
    1. For actuators loads the UPS output waveform shall conform to BS EN 50160.

PART 3 - EXECUTION

3.01 EXAMINATION:

A. Verify site conditions are suitable for installation of equipment. The area for installation shall be fully enclosed, weather tight, and free of contaminants.
B. Final or temporary HVAC systems shall be in place and operational to maintain the ambient temperatures and humidity conditions at occupancy levels prior to installation and shall be maintained for the remainder of the construction period.

3.02 INSTALLATION:

A. Install the UPS system and associated accessories as indicated.
B. Provide the required access for maintenance of the equipment.
C. The UPS system shall be put in operation per the manufacturer's recommendations.

3.03 FIELD QUALITY CONTROL:

A. Manufacturer’s Field Services:
    1. Manufacturer's field service shall be provided as specified in this Section and in Division 01.
    2. The manufacturer shall provide the field services of a factory technician for a minimum of 1 day to supervise/inspect installation, test and start-up all equipment provided. All travel and living expenses shall be included. All equipment required for testing, start-up and performance verification shall be provided by the start-up technician.
    3. Replacement parts shall be available 24 hours a day, 7 days a week, so the parts may be delivered to the customer site within 24 hours.
    4. Assist the Subcontractor in the setup and configuration of the network card and associated communications.

B. Field Testing:
   1. Prior to energization check all accessible connections to manufacturer's torque tightening specifications.
   2. Prior to energization, check for short-circuits.
   3. Perform “start-up” tests as recommended by manufacturer.
   4. Verify proper operation of alarm and status signals.

3.04 ADJUSTING AND CLEANING:

A. Prior to final acceptance all UPS units and associated equipment shall be wiped clean and free from dust.

B. If equipment interiors have been exposed to dust and other contaminates the Subcontractor shall provide the necessary interior cleaning of equipment. Use precaution and proper cleaning methods to avoid damage of equipment.

3.05 TRAINING:

A. The training session shall be of sufficient content and duration to provide a basic understanding of the hardware/software in general and specific instruction on the Site-specific implementation.

B. The UPS system supplier shall provide a minimum of 4 hours of training at the customer's facility for operations, maintenance and service personnel.
   1. The training session shall include classroom discussion on the theory of operation of the equipment, as well as maintenance and service methods for the equipment.
   2. Topics covered shall include safety, hardware layout and functions, power and control wiring, diagnostic indicators, keypad/display interface, faults, diagnostic tools, troubleshooting, and preventive maintenance.
   3. Hands-on training shall be provided on equipment.
   4. Documentation shall be provided which shall include actual manuals for the equipment and drawings and schematics of equipment supplied for this project.
   5. The training session shall be coordinated with Owner and Contractor.

C. Subcontractor shall record the training sessions and provide a final edited version to the Owner on a DVD-ROM and electronic video file format.

END OF SECTION 26 33 53

SECTION 26 43 13 – SURGE PROTECTIVE DEVICES FOR POWER DISTRIBUTION AND POINT-OF-SERVICE EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes parallel and series-wired, surge protective devices (SPDs) for service entrance and AC distribution equipment not exceeding 1000V, including disconnects, switchboards, motor control centers, panelboards, as well as point-of-service equipment, power for control panels, and control panel components.

1.02 RELATED REQUIREMENTS:

A. Section 26 24 16 - Panelboards
B. Section 40 66 00 - Process Control Networks
C. Section 40 67 00 - Process Control Panels and Hardware

1.03 REFERENCE STANDARDS:

A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.
B. National Fire Protection Association (NFPA):
    1. NFPA 70 – National Electrical Code (NEC)
        a. Article 285 – Surge-Protective Devices (SPDs) 1 kV or Less.
    2. NFPA 780 – Standards for the Installation of Lightning Protection Systems.
C. National Electrical Manufacturers Association (NEMA). Comply with applicable requirements of the following standards:
    1. NEMA 250 – Enclosures for Electrical Equipment (1,000V maximum).
D. Underwriters Laboratories (UL). Comply with applicable requirements of the following standards:
    1. UL 1283 – Electromagnetic Interference Filters.
    2. UL 1449 4th Edition – Surge Protective Devices.
E. Institute of Electrical and Electronic Engineers (IEEE) comply with applicable requirements of the following standard.
    1. IEEE C62.33 – Test Specifications for Varistor Surge-Protective Devices.
    2. IEEE C62.41.1 – Surge Environment in Low-Voltage (1000V and less) AC Power Circuits.
    3. IEEE C62.41.2 – Characterization of Surges in Low-Voltage (1000V and less) AC Power Circuits.
    4. IEEE C62.45 – Surge Testing for Equipment Connected to Low Voltage (1000V and less) AC Power Circuits.
    5. IEEE C62.62 – Test Specification for Surge Protective Devices for Low Voltage AC Power Circuitry.
    6. IEEE Std 1100 (Emerald Book) – Recommended Practice for Powering and Grounding Electronic Equipment.

SECTION 26 43 13 – SURGE PROTECTIVE DEVICES FOR POWER DISTRIBUTION AND POINT-OF-SERVICE EQUIPMENT

1.04 DEFINITIONS AND ABBREVIATIONS:

A. I-n: I-nominal rating.
B. MCOV: Maximum Continuous Operating Voltage rating.
C. MOV: Metal Oxide Varistors.
D. SAD: Silicon Avalanche Diodes.
E. SCCR: Short Circuit Current Rating.
F. SPD: Surge Protection Device.
G. VPR: Voltage Protection Rating.

1.05 SUBMITTALS:

A. In addition to the requirements of SECTION 01 33 00, submittals shall also include, but not be limited to, the following
    1. Product Data:
        a. Data sheets:
            (1) Physical details and dimensions.
            (2) Power input voltage and frequency.
            (3) Type category.
            (4) UL 1449 Listing documentation verifying the following:
                (a) Short Circuit Current Rating (SCCR).
                (b) Voltage Protection Ratings (VPRs) for all modes.
                (c) Maximum Continuous Operating Voltage rate (MCOV) for Type 1 and Type 2 SPDs.
                (d) I-nominal rating (I-n) for Type 1 and Type 2 SPDs.
                (e) Device type designation.
            (5) Peak surge current rating per phase.
        b. Tests, inspections: At the shop, factory, plant, or place of manufacture.
        c. Verification of performance: Compliance with specified criteria.

1.06 DELIVERY, STORAGE, AND HANDLING:

A. Integral SPDs shall be delivered, pre-installed, and stored according to the requirements of the distribution equipment or control panel in which they are installed.

1.07 SITE CONDITIONS:

A. All Equipment provided as part of this system shall be rated for the temperature, seismic and elevations as specified in the Site Conditions in Section 26 00 00.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

A. A manufacturer's presence on this list does not guarantee that all of its models are acceptable. The Subcontractor shall verify each SPD model meets all requirements of this specification.
B. AC Power Distribution Units:
    1. Advanced Protection Technologies, Inc.
    2. Eaton.

3. Erico International Corporation.
4. General Electric.
5. Mersen.
6. Schneider Electric.
7. Siemens.

2.02 GENERAL REQUIREMENTS FOR SURGE PROTECTIVE DEVICES:

A. UL 1449 4th Edition listed and labeled.
B. Shall be UL labeled as a Type 1 or Type 2 device, shall be intended to be installed on the load side of the service entrance equipment and shall not require external or supplemental overcurrent safety controls to meet UL 1449 4th Edition.
C. The surge protective device (SPD) shall be of a non-modular design using fast-acting transient energy protection that will divert and dissipate the surge energy.
D. Shall provide independent, directly-connected suppression components on each mode in the electrical distribution system, at least seven modes in Wye systems (L-N, L-G, N-G) and six modes (L-L, L-G) in Delta and impedance grounded Wye systems.
E. Shall be an integral or internally-mounted device as specified or indicated.
F. Shall use metal oxide varistor or MOV-hybrid technology as necessary. (Spark gaps, selenium cells and SCRs shall not be acceptable.)
G. Shall include internal fuses and thermally protection over every suppression component of every mode, including N-G unless protecting the service entrance.
H. Shall have integral, panel front status monitors or remote status panel ability as a minimum to indicate a continuous positive status of all protected modes, including N-G mode where applicable. Diagnostics shall be electrically isolated to prevent damage by surges.
I. Shall be UL labeled with a short circuit current rating of 200kA.
J. The maximum continuous operating voltage at 60 Hz shall be capable of sustaining at least 115% of the peak voltages continuously without degrading.
K. The maximum UL 1449 4th Edition Voltage Protection Ratings (VPR) for the device must not exceed the following:

Service	L-N	L-G	N-G	L-L	MCOV
120V 2-wire + Gnd	600V	1000V	600V	NA	150
120/240Vac 3-Wire + Gnd	700V	700V	700V	1200V	150

208/120Vac 3-phase, 3 or 4-wire	700V	700V	700V	1200V	150/276
480 Vac 3-phase, 3 Wire Delta	NA	1800V	NA	1800V	550
480/277 Vac 3-phase, 3-wire or 4-wire	1200V	1200V	1200V	2000V	550/320

L. Type 1 and Type 2 SPDs shall be UL labeled with 20kA I-n for compliance to UL 96A Lightning Protection Master Label and NFPA 780 with the following minimum protection characteristics:
   1. UL 1283 Listed. (Latest Edition)
   2. I_n: 20kA (per mode)
   3. SCCR: 100kAIC (minimum)
   4. MCOV: 550V
   5. UL Voltage Protection Rating:
      a. L-L: 1800V
      b. L-N, L-G, N-G: 900V
   6. Response time of less than 25 nanoseconds.

M. Provide SPDT contacts for remote indication. Contacts rated 5A at 120Vac minimum.

N. Equipped with an LED status indicator for verification that unit is functioning.

O. Minimum five year warranty.

2.03 SURGE PROTECTIVE DEVICE FOR DOWNSTREAM MOTOR CONTROL CENTERS, DISTRIBUTION PANELBOARDS:

A. The SPD shall be suitable for 480/277V, 3-phase, 4-wire 60Hz.

B. Downstream SPD units shall be tested and demonstrated suitable for application with ANSI/IEEE C62.41 Category B environments.

C. Shall have a peak surge current of 120kA per phase.

D. Minimum surge current capacity (I_{max}) of 40 kA per mode (8/20µs).

E. Internally-mounted units shall have a NEMA 1 enclosure designed for back panel or DIN rail mounting within a control panel or motor control center.

F. Shall include EMI/RFI filtering for ring wave suppression.

G. Shall have a minimum EMI/RFI filtering of -30dB at 100 kHz.

H. Minimum five year warranty.

2.04 SURGE PROTECTIVE DEVICE FOR POINT OF SERVICE EQUIPMENT

A. Surge suppressors shall be installed to protect at 120/208V 3-phase and 120/240V, 1-phase, 3-wire 60Hz distribution and process control panels.

1. Shall meet Type 2 SPD criteria with the following minimum protection characteristics:
   a. I_n: 20kA (per mode)
   b. SCCR: 100kAIC (minimum)
   c. MCOV: 150V (L-G), 270 (L-L).
   d. UL Voltage Protection Rating:
      (1) L-L: 1000V
      (2) L-N, L-G, N-G: 600V
2. Designed for 120/208V 3-phase or 120/240Vac, single-phase operation as required.
3. EMI/RFI filtering.
4. Peak clamping voltage of 320 volts line to neutral and 350 volts line to ground with Category B waveform.
5. Minimum surge current capacity of 10 kA per mode (8/20µs).
6. Response time of less than 25 nanoseconds.
7. Equipped with an LED status indicator for verification that unit is functioning.
8. NEMA 1 enclosure designed for back panel or DIN rail mounting within a control panel.

B. Panel I/O Surge Suppressors:
1. Provide DIN rail mounted terminal block type transient voltage surge suppressors for all inputs and outputs that are wired to devices located outside of the building envelope.
2. Provide surge suppressors for ethernet connections located outdoors between control panels.
3. Finger safe screw type terminals.
4. Replaceable surge modules.
5. Three-stage surge protection.
6. Provisions for labeling terminal block numbers.
7. Analog and 24Vdc Signal Surge Protection:
   a. Series surge suppressor.
   b. Minimum surge current capacity of 10 kA per mode (8/20µs).
   c. Minimum lightning surge current capacity of 500A per path (10/350µs).
   d. Maximum let thru voltage line to ground of 45 Vdc.
   e. Maximum let thru voltage line to line of 90 Vdc.
   f. Response time of less than 5 nanoseconds.
   g. Maximum series resistance of 10 ohms.
   h. Minimum continuous current rating of 300 mA.
8. 120Vac Discrete Signal Surge Protection:
   a. Series surge suppressor.
   b. Minimum surge current capacity of 4 kA per mode (8/20µs).
   c. Minimum lightning surge current capacity of 2.5 kA per path (10/350µs).
   d. Maximum let thru voltage line to ground 380 Vac.
   e. Maximum let thru voltage line to line of 600 Vac.
9. Minimum continuous current rating of 15A.
10. Response time of less than 25 nanoseconds.

C. Shall be designed to pass the appropriate IEEE testing standards included below:
1. IEEE C62.11.
2. IEEE C62.33.
3. IEEE C62.36.
4. IEEE C62.45.
5. IEEE C62.62.

2.05 ADDITIONAL REQUIREMENTS FOR PLUG-ON SPDS:

A. Shall be directly connected to the equipment bus bar through an integral circuit breaker sized as recommended by the manufacturer.
B. Shall include a display with a resettable counter for the combined total number of transient voltage surges detected since the counter was reset.

2.06 ADDITIONAL REQUIREMENTS FOR SPDS INTEGRAL TO THE POWER DISTRIBUTION EQUIPMENT:

A. The SPD shall be mounted to the equipment by a direct bus bar connection.
B. The SPD shall not limit the use of through-feed lugs, sub-feed lugs, or sub-feed breaker options.
C. The power distribution equipment shall be capable of re-energizing upon removal of the SPD.

2.07 ACCESSORIES:

A. Monitoring Diagnostics/Accessories:
    1. Protection Status Indicators - Each unit shall have a green/red solid-state indicator light that reports the status of the protection element on each phase.
        a. Wye configured units, shall have indication in the L-N and L-G and N-G modes.
        b. Delta configured units, shall have status indication in the L-G and L-L modes.
        c. The absence of a green light and the presence of a red light shall indicate that damage has occurred on the respective phase or mode. All protection status indicators must indicate the actual status of the protection on each phase or mode. If power is removed from any one phase, the indicator lights must continue to indicate the status of the protection on all other phases and protection modes. Diagnostics packages that simply indicate whether power is present on a particular phase shall not be accepted.
    2. Surge Event Counter: The SPD shall be equipped with an LCD display that indicates to the user how many surges have occurred at the location.
        a. The surge counter shall trigger each time a surge event with a peak current magnitude of a minimum of 50 ± 20A occurs. A reset pushbutton shall also be standard, allowing the surge counter to be zeroed. The reset button shall contain a mechanism to prevent accidental resetting of the counter via a single, short-duration button press. In order to prevent accidental resetting, the surge counter reset button shall be depressed for a minimum of 2 seconds in order to clear the surge count total.
        b. The ongoing surge count shall be stored in non-volatile memory. If power to the SPD is completely interrupted, the ongoing count indicated on the surge counter's display prior to the interruption shall be stored in non-volatile memory and displayed after power is restored. The surge counter's memory shall not require a backup battery in order to achieve this functionality.

2.08 FINISHES:

A. Manufacturer shall prepare surfaces, prime, and finish paint all surfaces with manufacturer's standard coating system. Coating system and color shall be suitable for intended services.

PART 3 - EXECUTION

3.01 EXAMINATION:

A. Examine area and location of equipment to receive SPDs for compliance with manufacturer's environmental conditions and other conditions affecting performance of the Work.
B. Examine field installed SPDs before installation. Reject SPDs that have been wet, moisture damaged, or physically damaged.
C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 GENERAL INSTALLATION REQUIREMENTS:

A. The installation of the surge suppression system shall be installed in strict accordance with the manufacturer's recommended practices and in compliance with the NEC.
B. The Subcontractor shall verify the proper application of the SPD (i.e. voltage, phases, etc.)
C. The Subcontractor shall verify that all neutral conductors are bonded to the system ground at the service entrance or at the serving transformer prior to installation of the SPD.
D. The phase, neutral and grounding conductors serving the SPD shall be gently twisted to reduce the SPD system inductance and shall be kept at the minimum length. Avoid any sharp bends and coils in the conductors.
E. Do not perform insulation resistance tests on a piece of electrical equipment with an SPD installed. SPDs are not designed to withstand the relatively high voltages applied for the duration of a megger test measured in seconds. Disconnect the SPD during insulation testing and reconnect immediately after testing is over.

3.03 INSTALLATION OF EXTERNALLY-MOUNTED SPDS:

A. Externally mounted SPDs are only permitted with Approval from the Contractor.
B. The SPD shall be located immediately adjacent or nippled to the equipment being protected to meet the manufacturer recommended installation.
C. Provide a disconnecting means or overcurrent protection and wiring as recommended by the manufacturer. When no recommendation is provided install the SPD through a 30-Amp circuit breaker using 10-gauge wire.
D. When installed at a service entrance, the SPD shall be installed on the load side of the main service disconnect overcurrent device.
E. When installed at a separately-derived system, the SPD shall be connected on the load side of the first overcurrent device.
F. When protecting a panelboard, switchboard or motor control center, install the SPD through a breaker as a disconnecting source per the manufacturer's installation

instructions. Installer may reasonably rearrange breaker locations to ensure short and straightest possible leads to SPD.

G. If the lead length exceeds 18-inches, the Subcontractor shall notify the Contractor and contact the surge suppression manufacturer for installation assistance.

H. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standard 468A and the National Electrical Code.

I. The SPD installation shall be certified by a licensed electrician that the installation is in accordance with the manufacturer's recommendations, applicable electrical code requirements, and the requirements of this specification. Any deficiencies noted shall be corrected by the Subcontractor. Provide written documentation of this inspection as part of the closeout documentation.

3.04 INSTALLATION OF INTERNALLY-MOUNTED SPDS:

A. When installed within a switchboard, motor control center, or panelboard, the SPD shall be installed in a dedicated bucket or space.

B. When installed within a control panel, the SPD shall be provided and installed by the control panel fabricator. Refer to Section 40 67 00 – Process Control Panels and Hardware.

C. Provide a disconnecting means or overcurrent protection and wiring as recommended by the manufacturer. When no recommendation is provided install the SPD through a 30-Amp circuit breaker using 10-gauge wire.

3.05 FIELD QUALITY CONTROL:

A. Perform tests and inspections: Inspect SPDs, modules, connections, and installation. Test and Inspect SPDs for proper function per manufacturers recommendations.

3.06 FINISHES:

A. Externally Mounted SPDs are permitted with approval of the Contractor: SPD enclosure coatings shall be free from scratches, rust, or other defects.

B. All damaged or defective coatings shall be repaired prior to final acceptance.

C. Field Painting:

1. Touch Up:
    a. Subcontractor shall prepare surfaces and touch up manufacturer applied coatings as required for any damage during shipment and installation.
    b. Field painting shall be performed based on manufacturer's recommended procedures.
    c. Subcontractor shall provide the necessary quantity of Manufacturer's touch-up paint to match the factory applied finish.

3.07 ADJUSTING AND CLEANING:

A. For externally mounted SPDs: After field installation and final wiring terminations are completed the SPD wiring and cables shall be adjusted and neatly secured with tie wraps, hook-and-loop straps, or the like.

B. Prior to final acceptance enclosure interior and exterior shall be wiped clean and free from dust and debris.

3.08 DEMONSTRATION:

A. Upon completion of installation of SPDs and associated electrical circuitry, energize circuitry and demonstrate functioning of equipment in accordance with manufacturer's requirements. Where possible, correct any malfunctioning units at the project site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and retest to demonstrate compliance.

3.09 TRAINING:

A. Provide a minimum of 1 hours of training for each type of SPD provided at the customer's facility for operations, maintenance, and service personnel.
   1. The training session shall include classroom discussion on the theory of operation of the equipment, as well as maintenance and service methods for the purchased equipment.
   2. Topics covered shall include safety, hardware layout and functions, power and control wiring, diagnostic indicators, keypad/display interface, faults, diagnostic tools, troubleshooting, and preventive maintenance.
   3. Hands-on training shall be provided on equipment. Specific training shall demonstrate the replacement procedures for SPD modules.
   4. Documentation shall be provided which shall include actual manuals for the equipment and drawings and schematics of equipment supplied for this project.

B. Subcontractor shall record the training sessions and provide a final edited version to the Owner on a video DVD-ROM and electronic video file format.

END OF SECTION 26 43 13

DIVISION 31 – EARTHWORK

SECION 31 20 00 – SITE PREPARATION AND EARTHWORK

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes Site preparation activities and certain items of earthwork common to other related Work.

B. Related Work Specified Elsewhere:

1. Demolition: SECTION 02 41 13.
2. Subgrade Preparation: SECTION 31 23 13.
3. Trenching and Backfilling for Utilities: SECTION 31 23 33.

1.02 REFERENCES:

A. Applicable Standards:

1. American Association of State Highway and Transportation Officials (AASHTO):
   a. M80 - Coarse Aggregate for Portland Cement Concrete.
   b. T99 - The Moisture-Density Relations of Soils Using a 5.5-Pound Rammer and a 12-Inch Drop.
   c. T104 - Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate.
   d. T180 - The Moisture-Density Relations of Soils Using a 10-Pound Rammer and an 18-Inch Drop.
2. American Society for Testing and Materials (ASTM):
   a. D2167 - Test Method for Density and Unit Weight of Soil In-Place by Rubber Balloon Method.
   b. D4253 - Test Method for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
   c. D4254 - Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
   d. D4318 - Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
   e. D4546 - Test Methods for One-Dimensional Swell/Settlement Potential of Cohesive Soils.
   f. D6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
3. State of Colorado Department of Transportation (CDOT) Standard Specifications for Road and Bridge Construction.
4. The subsurface exploration and geotechnical engineering report named "*Geotechnical Engineering Study and Pacement Thickness Design Proposed Wes Brown Wastewater Treatment Plant Silo and Equipment Building 3651 East 86th Avenue Thornton, Colorado*", by Kumar & Associates, Inc., dated October 23, 2025.
5. City of Thornton Standards and Specifications for the Design and Construction of Public and Private Improvements, current edition.

1.03 SUBMITTALS:

A. Submit as specified in DIVISION 1.

B. Imported fill material data.

C. On-site material data.

D. Dewatering Plan, as required.

E. Sheeting and Shoring Excavation Plan, as required.

PART 2 - PRODUCTS

2.01 EARTHWORK:

A. Materials suitable for use in embankment and fill include material free of debris, roots, organic matter, and frozen matter; and free of stone having any dimension greater than 2 inches in areas requiring a high degree of compaction or 4 inches in other embankment and fill areas:
   1. Cohesionless/granular materials include gravels, gravel-sand mixtures, sands, and gravelly sands exclusive of clayey material:
      a. Free-draining.
      b. For which generally less than 15% by dry weight, of soil particles pass the No. 200 sieve.
   2. Cohesive materials include silts and clays generally exclusive of sands and gravel:
      a. Materials for which impact compaction will produce a well-defined, moisture-density relationship curve.

B. Materials unsuitable for use in embankment and fill include all material that contains debris, roots, organic matter, frozen matter, gravel, stone, or shale particles with any dimension greater than 2 inches in areas requiring a high degree of compaction or 4 inches in other embankment and fill areas, or other materials that are determined by Engineer to be too wet or otherwise unsuitable for providing a stable subgrade or stable foundation for structures.

C. Material for Embankment or Fill:
   1. Borrow materials shall not exhibit characteristics of high shrink-swell potential as determined from Atterberg limit tests (ASTM D4318) and/or swell/pressure tests (ASTM D4546).
   2. For soils used below structural elements, such as footings, slabs, pavements, and mats, that portion of material passing the No. 40 square-mesh sieve shall have a liquid limit not exceeding 40 and a plasticity index not exceeding 25 when tested in accordance with ASTM D4318.

D. Waste materials include excess usable materials and materials unsuitable for use in the Work, in accordance with this Specification.

E. Borrow materials include all fill materials and topsoil obtained from locations off the Site:
   1. Material shall be subject to approval of Engineer.
   2. Borrow areas shall be as follows:
      a. Arranged for by Contractor at no additional cost to Owner.
      b. Subject to approval of Engineer.

PART 3 - EXECUTION

3.01 SITE PREPARATION:

A. Clearing and Grubbing:
   1. Perform clearing and grubbing as indicated or as necessary to perform excavation, trenching, embankment, borrow, and other Work required, and where desired by Contractor for subsidiary purposes subject to approval:
      a. Clearing:
         (1) Includes felling and disposal of trees, brush, and other vegetation.
         (2) Conduct Work in a manner to prevent damage to property and to provide for the safety of employees and others.
         (3) Keep operations within property lines as indicated.
      b. Grubbing:

(1) Includes removal and disposal of tree stumps and roots larger than 3 inches in diameter.
(2) Remove to a depth of at least 18 inches below existing grade elevation.
(3) Backfill all excavated depressions with approved material and grade to drain.

B. Demolition:
1. For additional specifications related to demolition, see SECTION 02 41 13 - DEMOLITION.
2. General Requirements:
a. Remove existing construction to limits indicated or as required to perform new construction. Remove materials from Site, or store and reuse as specified or as indicated.
3. Operation of Existing Facilities:
a. Make provisions for temporarily accommodating flows in existing facilities.
4. Protection of Existing Structure and Property:
a. Perform demolition Work to ensure existing structure or property which is to remain against damage from operations, falling debris, or other causes.
b. Take precautions to guard against movement or settlement; use sheeting and bracing where required by the Specifications or Drawings and where resulting slopes from excavation or trenching might endanger structures or utilities.
c. If at any time safety of existing structure to remain is endangered, cease operations and notify Engineer. Do not resume operation prior to approval.
5. Handling and Storage:
a. Carefully dismantle Equipment and Materials to be reused in a manner to avoid damage. Repair or replace any Material or Equipment damaged by Contractor's operations, as determined by Owner.
b. Store Equipment and Materials to be reused in a manner to avoid corrosion, staining, breakage, or damage from any cause.
c. Remove concrete by jackhammering, sawing, core-drilling, or other acceptable method.

C. Stripping:
1. Remove topsoil from areas within limits of excavation, trenching, and borrow and areas designated to receive embankment and compacted fill as follows:
a. Scrape areas clean of all brush, grass, weeds, roots, and other materials.
b. Strip to a sufficient depth to remove excessive roots in heavy vegetation or brush areas and as required to segregate topsoil.
c. Stockpile topsoil in areas designated where it will not interfere with construction operations or existing facilities. Stockpiled topsoil shall be reasonably free of subsoil, debris, and stones larger than 2-inch diameter.

D. Debris:
1. Dispose of debris from clearing, grubbing, stripping, and demolition at a location off the Site as arranged for by Contractor.

3.02 EARTHWORK:

A. Excavation:
1. Expected site conditions are as documented in the subsurface exploration and geotechnical engineering report named "*Geotechnical Engineering Study and Pacement Thickness Design Proposed Wes Brown Wastewater Treatment Plant Silo and Equipment*

Building 3651 East 86th Avenue Thornton, Colorado", by Kumar & Associates, Inc., dated October 23, 2025.

2. Perform excavation as indicated or as required to complete the Work.
3. Blasting: Blasting shall not be permitted.
4. Dewatering:
   a. Expected groundwater conditions are as documented in the subsurface exploration and geotechnical engineering report named "*Geotechnical Engineering Study and Pavement Thickness Design Proposed Wes Brown Wastewater Treatment Plant Silo and Equipment Building 3651 East 86th Avenue Thornton, Colorado*", by Kumar & Associates, Inc., dated October 23, 2025.
   b. General:
      (1) Contractor shall design and provide the dewatering system using accepted and professional methods of design and engineering consistent with the best current practice to eliminate water entering the excavation under hydrostatic head from the bottom and/or sides. The system shall be designed to prevent differential hydrostatic head which may occur from rising water levels from adjoining or nearby bodies of water, proximity of excavation to phreatic groundwater level, or surface runoff, and which would result in floating out soil particles in a manner termed as a "quick" or "boiling" condition. System shall not be dependent solely upon sumps and/or pumping water from within the excavation where differential head would result in a "quick" condition, which would continue to worsen the integrity of the excavation's stability.
      (2) Provide dewatering system of a sufficient size and capacity as required to control ground and surface water flow into the excavation and to allow all Work to be installed in a dry condition, including the obtaining of a licensed well-driller, where required.
      (3) Control, by acceptable means, all water regardless of source and be fully responsible for disposal of the water.
      (4) Confine all discharge piping and/or ditches to the available easement or to additional easement obtained by Contractor. Provide all necessary means for disposal of the water, including the obtaining of all necessary permits and of additional easement at no additional cost to Owner.
      (5) Control groundwater in a manner that preserves the strength of the foundation soils, does not cause instability or raveling of the excavation slopes, and does not result in damage to existing structures. Where necessary to these purposes, lower the water level in advance of excavation, using wells, wellpoints, jet eductors, or similar positive methods. The water level as measured in piezometers shall be maintained a minimum of 3 feet below the prevailing excavation level.
      (6) Commence dewatering with means to provide positive dewatering of all water sources prior to any appearance of water in excavation and continue until Work is complete to the extent that no damage results from hydrostatic pressure, flotation, or other causes.
      (7) Open pumping with sumps and ditches shall be allowed, provided it does not result in boils, loss of fines, softening of the ground, or instability of slopes.
      (8) Install wells and/or wellpoints, if required, with suitable screens and filters, so that continuous pumping of fines does not occur. Arrange the discharge to facilitate collection of samples by Owner or Resident Project Representative. During normal pumping, and upon development of well(s), levels of fine

sand or silt in the discharge water shall not exceed 5 ppm. Install a sand tester on the discharge of each pump during testing to verify that levels are not exceeded.

(9) Install, operate, and maintain the dewatering system required to control surface and/or groundwater.

(10) Control grading around excavations to prevent surface water from flowing into excavation areas.

(11) Drain or pump as required to continually maintain all excavations and trenches free of water or mud from any source, and discharge to approved drains or channels. Commence when water first appears and continue until Work is complete to the extent that no damage will result from hydrostatic pressure, flotation, or other causes.

c. Damages:

(1) Contractor shall be responsible for and shall repair without cost to Owner any damage to work in place, other Contractor's equipment, utilities, residences, highways, roads, railroads, private and municipal well systems, adjacent structures, and the excavation, including, damage to the bottom due to heave and including but not limited to, removal and pumping out of the excavated area that may result from Contractor's negligence, inadequate or improper design and operation of the dewatering system, and any mechanical or electrical failure of the dewatering system.

(2) Remove subgrade materials rendered unsuitable by excessive wetting and replace with approved backfill material at no additional cost to Owner.

d. Maintaining Excavation in Dewatered Condition:

(1) Dewatering shall be a continuous operation.

(2) Continuously maintain excavation in a dry condition with positive dewatering methods during preparation of subgrade, installation of pipe, and construction of structures until the critical period of construction and/or backfill is completed to prevent damage of subgrade support, piping, structure, side slopes, or adjacent facilities from flotation or other hydrostatic pressure imbalance.

(3) Provide standby equipment on site, installed, wired, and available, for immediate operation if required to maintain dewatering on a continuous basis in event any part of system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, perform such work as may be required to restore damaged structures and foundation soils at no additional cost to Owner.

e. System Removal:

(1) Contractor shall remove all dewatering equipment from the Site, including related temporary electrical service.

(2) All wells shall be removed or cut off a minimum of 3 feet below the final ground surface, capped, and abandoned in accordance with regulations by agencies having jurisdiction.

(3) Removal work required under this paragraph does not include any of the site cleanup work as required elsewhere in these Specifications.

5. Stockpiling:

a. Stockpile in amounts sufficient for and in a manner to segregate materials suitable for the following:

(1) Topsoiling.

(2) Constructing embankments and fills.
(3) Backfilling.
(4) Waste only.

b. Do not obstruct or prevent access to:
(1) Roads and driveways.
(2) Utility control devices.
(3) Ditches or natural drainage channels.

c. Perform in a manner to avoid endangering the Work, stability of banks or structures, or health of trees and shrubs to be saved.

d. Maintain safe distance between toe of stockpile and edge of excavation or trench.

e. Stockpile excess soil on Site in area designated by Owner.

6. Waste Materials:

a. Waste materials as described for purposes of this Contract within this Section consist of deleterious soils, rock, and other materials considered unacceptable for compaction or placement fill, and which are not environmentally contaminated. Waste materials shall not include environmental pollutants, hazardous substances, contaminated products, by-products, samples, or waste materials of any kind that are regulated under environmental laws.

b. Remove waste materials from Work area as excavated.

c. Disposing of Waste Material:
(1) Consult the Owner on locations to deposit waste materials.

d. Grade waste areas and leave them free draining and with an orderly and neat appearance.

B. Embankment:

1. Construct embankments to the contours and elevations indicated, using suitable approved material from excavations and borrow areas:

a. Borrow:
(1) Refers to all fill materials and topsoil obtained from approved locations off the Site.
(2) Borrow shall include all excavating, handling, and final disposal of materials as specified.
(3) Borrow areas shall be:
(a) Arranged for by Contractor at no additional cost to Owner.
(b) Subject to approval.
(4) Material removed from borrow areas shall be as approved.
(5) Leave borrow areas graded to drain and to present a neat appearance.

b. Compaction:
(1) Compact embankments using equipment as required to obtain reasonable uniformity.
(2) Compaction shall be as obtained by normal methods and equipment during the placing and grading of layers and to the minimum density specified for particular locations.

c. Placement:
(1) Place fill material in 4-inch to 8-inch layers in all areas.
(2) Place embankment only on subgrades approved by Engineer.
(3) Do not place snow, ice, or frozen earth in fill; do not place fill on a frozen surface.

C. Subgrades:

1. General:

a. Excavate or fill as required to construct subgrades to the elevations and grades indicated.
b. Remove all unsuitable material and replace with approved fill materials.
c. Perform all wetting, drying, shaping, and compacting required to prepare a suitable subgrade.
d. Exposed area to receive fill, backfill, or embankment shall be proof-rolled to detect localized zones of excessively wet, unstable, organic, or low bearing capacity materials to the extent as follows:
(1) Proof-roll as a single-pass operation with conventional compaction equipment during subgrade preparation and prior to placement of fill, and as a spot check process without the need for complete coverage per unit area of tire. Soft spots will be over-excavated, backfilled and compacted with suitable material.

2. Subgrade for Fills and Embankment: Roughen by disking or scarifying. Wet or dry top 8 inches, as required, to bond with fill or embankment.
3. Subgrade for Access Roadways, Drives, Parking Areas and Trails:
a. Extend subgrade the full width of the roadbed plus 1 foot outside the edges of the overlying course to be placed.
b. Subgrades shall be scarified moisture conditioned and re-compacted.
c. Proof roll prepared subgrade surface to check for unstable areas and areas requiring additional compaction. Notify Engineer of unsatisfactory conditions. Do not begin road surfacing placement until deficient subgrade areas have been corrected and are ready to receive surfacing.

D. Site Grading:
1. Excavate, fill, compact fill, and rough grade to bring Project area outside of structures to subgrades as follows:
a. For surfaced areas, to underside of respective surfacing or base course:
b. Prepare subgrades as specified in this Section.
c. For seeded areas, to 4 inches below finished grade.
2. Rock:
a. Includes rock encountered in grading areas outside of structure limits.
b. Excavate rock to depths as follows:
(1) Under surfaced areas, to 6 inches below the top of respective subgrades.
(2) Under seeded areas, to 24 inches below finished grade:
(a) Boulder or protruding rock outcrop shall be left undisturbed where approved.
c. Backfill to grade with approved earth fill compacted-in-place:
(1) Achieve minimum density specified for particular location.
3. Fill:
a. Fill as required to raise existing grades outside of structure areas to the new grades as indicated.
b. Such fill shall be performed as specified herein.
c. Remove all debris subject to termite attack, rot, or corrosion from areas to be filled.
4. Rough Grading:
a. All areas within the Project, including excavated and filled sections, and adjacent transition areas shall be reasonably smooth, compacted, and free from irregular surface changes.

b. Degree of finish shall be that ordinarily obtained from blade grader or scraper operations, except as otherwise specified.
c. Finished rough grades shall generally be not more than 0.5 foot above or below established grade or approved cross sections with due allowance for topsoil and sod.
d. Tolerance for areas within 10 feet of structures shall not exceed 0.15 foot above or below established subgrade.
e. Finish all ditches, swales, and gutters to drain readily.
f. Unless otherwise indicated, slope the subgrade evenly to provide drainage away from structure walls in all directions at a grade not less than 1/4 inch per foot.
g. Provide roundings at top and bottom of banks and at other breaks in grade.

E. Topsoiling:
1. Includes placement of topsoil on all areas not specified to receive paving or other surface treatment including borrow or waste areas.
2. Materials:
a. Those obtained from excavation which are most suitable and stockpiles for such purpose:
(1) Topsoil shall be a fertile, friable, and loamy soil of uniform quality, free from materials such as hard clods, stiff clay, stone with any dimension greater than 1 inch, and similar impurities. Relatively free from grass, roots, weeds, and other objectionable plant material.
b. Borrow when required.
3. Subgrade Treatment:
a. Clear Site of vegetation heavy enough to interfere with proper grading and tillage operations.
b. Clear surfaces of all stones or other objects larger than 3 inches in thickness or diameter, all roots, brush, wire, grade stakes, or other objectionable material.
c. Loosen subgrade by disking or scarifying to a depth of 2 inches wherever compacted by traffic or other causes to permit bonding of the topsoil to the subgrade.
4. Placement of Topsoil:
a. Distribute over required areas without compaction in upper 1 foot, other than that obtained with spreading equipment.
b. To extent material is available within following limits:
(1) Not less than 4 inches in depth.
(2) Do not exceed 2 feet in depth.
(3) Shape cuts, fills, and embankments to contours indicated.
(4) Grade to match contours of adjacent areas and permit good, natural drainage. Provide gentle mound over trenches.
5. Maintenance:
a. After topsoil has been spread, clear surface of stones or other objects larger than 1 inch in thickness or diameter and all other objects that might interfere with planting and maintenance operations.
b. Protect topsoiled areas from the elements until grass is established and repair eroded areas as required.
c. Keep paved areas clean. Promptly remove topsoil or other dirt dropped upon surfacing.

3.03 FIELD QUALITY CONTROL:

A. Compaction:
   1. Engineer will, through services of an independent laboratory, test all embankments, fills, and subgrades under this Contract to determine conformance with specified density relationships.
   2. Method of test may be either of the following at Contractor's option:
      a. ASTM D2167.
      b. ASTM D6938.
   3. Testing frequency:
      a. 1 density test per 500 sq. ft. per lift.
      b. 1 moisture content test per 500 sq. ft. per lift.
   4. Failed tests requiring re-testing shall be at the cost of the Contractor. Contractor will make arrangements with the Engineer for direct reimbursement.

B. Subgrades:
   1. Engineer will inspect all subgrades to determine conformance with indicated lines and grades.
   2. Subgrades for roadways, drives, and parking areas should be thoroughly scarified and well-mixed to a depth of 12 inches, adjusted to a moisture content between 0 to +3 percentage points of the optimum moisture content for cohesive subgrades, and within 2 percentage points of the optimum moisture content for granular subgrades and compacted to at least 95% of the standard proctor (ASTM D 698) maximum dry density.
   3. Subgrades for roadways, drives, and parking areas shall have a maximum deviation of not more than 1inch in any 10 feet when tested with a 10-foot straightedge applied parallel with and at right angles to the centerlines of subgrade areas.

3.04 PROTECTION OF THE WORK:

A. Maintenance:
   1. Protect newly graded and topsoiled areas from actions of the elements.
   2. Fill and repair settling or erosion occurring prior to landscaping and reestablish grades to the required elevations and slopes.

END OF SECTION 31 20 00

SECTION 31 23 13 – SUBGRADE PREPARATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY:

A. This Section covers subgrade preparation for asphalt and concrete pavement.

1.03 RELATED REQUIREMENTS:

A. Crushed Rock Base Course: Section 32 11 23.
B. Asphalt Paving: Section 32 12 16.

1.04 DEFINITIONS:

A. Unsuitable Material:
   1. Material encountered in excavation areas classified by Engineer as "organic silt" or "organic clay" when tested to conform to ASTM D2488.
B. In situ moisture content outside the range necessary for preparation of subgrade will not be cause for classification as unsuitable material.

1.05 REFERENCES:

A. Applicable Standards:
   1. ASTM International (ASTM):
      a. D698 - Test Method for Laboratory Compaction Characteristic of Soil Using Standard Effort 12,400 ft-lbf/ft^3.
      b. D1556 - Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
      c. D1557 - Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort 56,000 ft-lbf/ft^3.
      d. D2167 - Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
      e. D2488 - Practice for Description and Identification of Soils (Visual Manual Procedure).
      f. D2937 - Test Method for Density of Soil in Place by the Drive-Cylinder Method.
      g. D6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
   2. City of Thornton Standards and Specifications for the Design and Construction of Public and Private Improvements, current edition.

PART 2 - PRODUCTS

2.01 GENERAL:

A. Equipment includes all units necessary to construct subgrade conforming to requirements specified, such as, but not limited to:
   1. Scarifiers.
   2. Discs.
   3. Water distributor.
   4. Blade graders.
   5. Subgrade planers.

6. Templates, straightedges, and other devices necessary to accurately check grade and crown.
7. Pneumatic rollers.
8. Tamping rollers.
9. Self-propelled, steel-wheel rollers.

2.02 PNEUMATIC ROLLERS:

A. Self-propelled.
B. Two axles with not less than nine wheels using pneumatic tires.
C. Rigid steel frame and body suitable for ballast loading.

2.03 TAMPING ROLLERS:

A. Towed or self-propelled.
B. Staggered, uniformly spaced knobs or feet exerting not less than 250 psi on combined area in contact with the ground.
C. Equipped with cleaning fingers maintained at full length to prevent accumulation of material between the feet.

2.04 STEEL-WHEEL ROLLERS:

A. Self-propelled tandem or three-wheel.
B. Weight not less than 10 tons.
C. Equipped with scrapers to prevent accumulation of material on the rollers.

2.05 SUBGRADE PLANERS:

A. Designed to roll on forms or be electronically controlled by erected stringline or other reference.
B. Adjustable to produce a subgrade of exact elevation and cross section specified.

PART 3 - EXECUTION

3.01 PREPARATION:

A. Prepare and maintain subgrade at the time the overlying pavement, base course, curb, walk, subbase course, paved drainage, slab-on-grade, or other surfacing is constructed thereon.
B. Remove unsuitable material to the limits designated by Engineer and replace with suitable embankment material.

3.02 CONSTRUCTION REQUIREMENTS:

A. Grade and compact subgrade to meet specified requirements.
B. Extend subgrade 6 inches, or such greater distance as is necessary, for support of equipment and forms used to place the overlying material beyond the limits of the overlying course.
C. Moisture Control:
    1. Aerate, dry, or add moisture if necessary to produce a finished subgrade that is nonyielding and meets specified density.
    2. Scarify and disc subgrade material in both excavation and embankment areas having a moisture content too high to permit preparation of subgrade meeting specified requirements.
    3. Depth of manipulation shall be not less than 6 inches in all areas nor greater than 18 inches in excavation areas.

4. Contractor may, without cost to Owner, remove and replace or stabilize-in-place by acceptable methods, subgrade materials in lieu of adjusting the moisture content of in situ subgrade materials.

3.03 COMPACTION:

A. Compact subgrade to 95% of maximum density at optimum to +3 points above optimum moisture (cohesive material) or within 2 points of optimum (granular materials), as determined by ASTM D1557 for:
   1. All areas 6 inches or more below finish subgrade elevation.
   2. Sidewalks.
   3. Nontraffic medians.
   4. Paved drainage.
   5. Residential driveways.
   6. Slabs-on-grade except Portland cement concrete pavement.

B. Compact subgrade to 95% of maximum density at optimum to +3 points above optimum moisture (cohesive material) or within 2 points of optimum (granular materials), as determined by ASTM D1557 for:
   1. Curbs.
   2. Curb and gutter.
   3. All flexible and rigid pavement and base course, except residential driveways.

C. Moisture Content of Subgrade:
   1. Keep within the applicable moisture range necessary to permit preparation of subgrade to conform to requirements specified.
   2. Applicable moisture varies with specific materials, and may be at, above, or below the optimum moisture content determined by ASTM D1557.
   3. Determine the applicable moisture range necessary to obtain subgrade-in-place by use of Contractor 's equipment and construction procedures.

3.04 SURFACE TOLERANCES:

A. Surface Tolerances:
   1. Maximum Compensating Deviation from Grade and Cross Section:
      a. ±0.02 ft. for flexible and rigid pavement and bases, except driveways.
      b. ±0.04 ft. for all other subgrade.

B. Test the completed subgrade for conformance to specified tolerances by means of straightedge, stringline, template, or other approved devices.

C. Rework areas deviating from the specified tolerances by removing material from high spots and placing material in low areas.

3.05 FIELD QUALITY CONTROL:

A. Contractor shall, through services of an independent laboratory, test density and moisture content of the completed subgrade.

B. Tests will conform to ASTM D1556, ASTM D2167, ASTM D2937, or ASTM D6938 at Engineer's option.

C. Construct succeeding courses on prepared subgrade only after it has been tested and approved by Engineer.

3.06 MAINTENANCE:

A. Maintain completed subgrade in finished condition until the overlying pavement or base course is placed.

B. Restore all completed subgrade damaged prior to construction of the overlying course.
C. Engineer's approval of subgrade at the time of its completion does not relieve Contractor of the requirement to maintain subgrade until such time as the overlying material is in place.

END OF SECTION 31 23 13

SECTION 31 23 16 - EXCAVATION, FILLING, AND BACKFILLING FOR STRUCTURES

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes all necessary excavation, filling, and backfilling for structures and all related Work, including duct banks and manholes.

B. Related Work Specified Elsewhere:

1. Site Preparation and Earthwork: SECTION 31 20 00.
2. Trenching and Backfilling for Utilities: SECTION 31 23 33.
3. Concrete: DIVISION 3.

1.02 REFERENCES:

A. Applicable Standards:

1. American Association of State Highway and Transportation Officials (AASHTO):
   a. T99 - The Moisture-Density Relations of Soils Using a 5.5-lb Rammer and a 12-Inch Drop.
2. American Society for Testing and Materials (ASTM):
   a. D4253 - Test Method for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
   b. D4254 - Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
3. Occupational Safety and Health Administration (OSHA):
   a. Part 1926 - Safety and Health Regulations for Construction.
4. City of Thornton Standards and Specifcations for the Design and Construction of Public and Private Improvements, current edition.

1.03 SUBMITTALS:

A. Submit as specified in DIVISION 1.

B. Where selecting an option for excavation, trenching, and shoring in compliance with local, state, or federal safety regulations such as "OSHA Part 1926" or successor regulations, which require design by a registered professional engineer, submit the following:

1. Copies of design calculations and notes for sloping, benching, support systems, shield systems, and other protective systems prepared by or under the supervision of a professional engineer legally authorized to practice in the jurisdiction where the Project is located.
2. Documents provided with evidence of registered professional engineer's seal, signature, and date in accordance with appropriate state licensing requirements.

PART 2 - PRODUCTS

2.01 GENERAL EARTH BACKFILL:

A. Use suitable material as specified in SECTION 31 20 00.

2.02 STRUCTURAL FILL:

A. May consist of reconditioned on-site soils, or imported material consisting of a non-expansive material containing:

1. Maximum of 30% passing the No. 200 sieve.
2. Liquid limit (LL) less than 30.
3. Plasticity Index (PI) less than 15.

4. Materials not meeting the above criteria may be acceptable if they exhibit no ore than 1% swell when remolded to 95% of the standard proctor (ASTM D698) maximum dry density at a moisture content between -1 and +3 percentage points of optimum upon wetting under a constant 200 psf surcharge.
5. Fill material should not contain particles larger than 3-inches and should be free of any organic matter and other deleterious substances that could decay over time.

2.03 CONCRETE:

A. Includes all concrete used to restore bottom of excavation to proper elevation, and in concrete seal coats.
B. Concrete shall be as specified in DIVISION 3.

PART 3 - EXECUTION

3.01 EXCAVATION:

A. Perform as specified in SECTION 31 23 33 and as follows:
   1. Excavate area adequate to permit efficient erection and removal of forms.
   2. Trim to neat lines where details call for concrete to be deposited against earth.
   3. Excavate by hand in areas where space and access will not permit use of machines.
   4. If loose or soft zones are encountered that do not improve with subgrade preparation, over excavate and restore bottom of excavation to proper elevation with compacted structural fill in areas overexcavated, as approved.
   5. Use sides of trenches to form sides of duct banks where possible and where sides of trench are vertical, stable, and excavated to the proper line.
   6. Design, furnish, place, maintain, and subsequently remove, to the extent required, a system of temporary supports for cut and cover, open cut, or trench excavations, including bracing, dewatering, and associated items to support the sides and ends of the excavations where excavation slopes might endanger in-place or proposed improvements, extend beyond construction right-of-ways, or where specified or indicated.
   7. Space and arrange sheeting and bracing as required to exclude adjacent material and according to the stability of excavation slopes.
   8. Contractor shall make his own assessment of existing conditions including adjacent property, the possible effects of his proposed temporary works and construction methods, and shall select and design such support systems, methods, and details as will assure safety to the public, adjacent property, and the completed Work.
   9. Modify or relocate Underground Facilities, at no additional cost to Owner or Engineer, if existing Underground Facilities interfere with Contractor's proposed method of support.
   10. Employ caution in the areas of Underground Facilities, which shall be exposed by hand or other excavation methods acceptable to Owner.
   11. Perform sheeting, shoring, and bracing for trench excavation, for Underground Facilities, and for other purposes in accordance with the safety and protection requirements of the General Conditions.
   12. Provide sheeting, shoring, and bracing for trench excavation in the subgrade of the excavation to prevent movement of the main excavation support system.
   13. Provide shoring, sheeting, and bracing as indicated or specified to meet the following requirements:

a. Prevent undermining and damage to all structures, buildings, Underground Facilities, pavements and slabs.
b. Excavations shall be accomplished with vertical banks where necessary for construction activities or as indicated, and also within all limits of excavation noted on the Drawings.
c. Design excavation support system and components to support lateral earth pressures, unrelieved hydrostatic pressures, utility loads, traffic and construction loads, and building and other surcharge loads to allow the safe and expeditious construction of the permanent structures without movement or settlement of the ground, and to prevent damage to or movement of adjacent buildings, structures, Underground Facilities, and other improvements. The design shall account for staged removal of bracing to suit the sequence of concrete placement for permanent structures and backfill.
d. Except as otherwise specified herein, shoring and sheeting materials may be extracted and reused at Contractor's option; however, Contractor shall remove and replace any existing structure or Underground Facility damaged during shoring and sheeting. Remove sheeting and bracing as backfill progresses. Fill voids left after withdrawal with sand or other approved material.
e. Where shoring and sheeting materials must be left in-place in the completed Work to prevent settlements or damage to adjacent structures or as directed by Resident Project Representative, backfill the excavation to within 3 feet below the finished grade and remove the remaining exposed portion of the shoring before completing the backfill. If soldier piles and wood lagging are used for shoring, remove wood lagging to within 3 feet of finished grade in incremental steps of approximately 6 inches as the backfill is constructed, or to Contractor's design if more stringent. The location of all shoring and sheeting left in-place shall be documented on drawings and provided to Engineer and Owner.

14. Contractor shall be solely responsible for proper design, installation, operation, maintenance, and any failure of any component of the system. Review by Engineer of the design and data submitted by Contractor shall not relieve Contractor from full responsibility for errors therein or from the entire responsibility for complete and adequate design and performance of the sheeting and shoring system.
15. Provision for Contingencies:
    a. The performance of the components of the support system shall be monitored for both vertical and horizontal movement daily.
    b. A contingency plan or alternative procedure shall be provided for implementation, if the designed system does not adequately perform.
    c. The materials and equipment necessary to implement the contingency plan shall be kept readily available.
16. Damages:
    a. Contractor shall document all existing damage to adjacent facilities and submit the information to Owner prior to performing any excavation. Documentation shall include a written description, diagrams, measurements, and appropriate photographs.
    b. Repair all damage resulting from Contractor's excavation and remove and replace all undermined pavements with Owner-approved equal, either concrete or asphalt, at Contractor's expense.

3.02 FILLING AND BACKFILLING:

A. Sturctural Backfill under and adjacent to Foundations:
   1. Place in maximum of 8-inch uncompacted lifts.
   2. For concrete elements that retain unbalaced soil loads (e.g. basins) backfill only after concrete has attained 100% of design strength. For all other concrete elements, backfill only after concrete has attained 70% of the design strength.
   3. Backfill adjacent to structures only after, in the opinion of Engineer, a sufficient portion of the structure has been built to resist the imposed load.
   4. Remove all debris from excavation prior to placement of material.
   5. Perform backfilling simultaneously on all sides of structures.
   6. Exercise extreme care in the use of heavy equipment in areas adjacent to structures.
   7. Degree of compaction shall be as follows for new site grading fill and structural fill:
      a. Beneath shallow foundations 98%
      b. Against shallow foundations 95%
      c. Utility trench backfill 95%
      d. All site aggregate base course 95%
   8. Moisture content shall be as follows:
      a. Granular materials shall be compacted at moisture contents within 2 percentage points of the optimum moisture content.
      b. Clayety materials shall be compacted at moisture contents between 0 and +3 percentage points of the optimum moisture content.

3.03 FIELD QUALITY ASSURANCE:

A. Compaction:
   1. Engineer will, through services of an independent laboratory, test all filling and backfilling for structures to determine conformance with density relationships specified.
   2. Method of test shall be as specified in SECTION 31 20 00.
   3. The frequency of tests shall be in compliance with jurisdictional requirements or as otherwise required by Owner.

END OF SECTION 31 23 16

SECTION 31 23 33 - TRENCHING AND BACKFILLING FOR UTILITIES

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes:
   1. Excavation, sheeting, bracing, cutoof walls, and all operations necessary for the preparation of trenches for bedding of pipes and pipe appurtenances, conduit, and buried cable.
   2. Pipe embedments and encasements.
   3. Backfilling of trenches.

B. Related Work Specified Elsewhere:
   1. Site Preparation and Earthwork: SECTION 31 20 00.
   2. Concrete: DIVISION 3.

1.02 REFERENCES:

A. Applicable Standards:
   1. American Association of State Highway and Transportation Officials (AASHTO):
      a. M147 - Materials for Aggregate and Soil-Aggregate Subbase, Base and Surface Courses.
      b. T99 - The Moisture-Density Relations of Soils Using a 5.5-Pound Rammer and a 12-Inch Drop.
      c. T104 - Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate.
   2. American Society for Testing and Materials (ASTM):
      a. D1557 – Test Method for Laboratory Compation Characteristics of Soil Using Modified Effort 56,000 ft-lbf/ft^3.
      b. D4253 - Test Method for Maximum Index Density of Soils Using a Vibratory Table.
      c. D4254 - Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
   3. Occupational Safety and Health Administration (OSHA):
      a. Part 1926 - Safety and Health Regulations for Construction.
   4. Colorado Department of Transportation (CDOT) Standard Specifications for Road and Bridge Construction.
   5. The subsurface exploration and geotechnical engineering report named "*Geotechnical Engineering Study and Pavement Thickness Design Proposed Wes Brown Wastewater Treatment Plant Silo and Equipment Building 3651 East 86th Avenue Thornton, Colorado*", by Kumar & Associates, Inc., dated October 23, 2025.
   6. City of Thornton Standards and Specifications for the Design and Construction of Public and Private Improvements, current edition.

1.03 SUBMITTALS:

A. Submit as specified in DIVISION 1.

B. Includes, but not limited to, the following:
   1. Concrete Submittals as specified in DIVISION 3.
   2. Material submittals and tests to meet specifications (bedding and backfill).
   3. Select pipe embedment and backfill characteristics and gradation.

C. Where selecting an option for excavation, trenching, and shoring in compliance with local, state, or federal safety regulations such as "OSHA Part 1926" or successor regulations, which

require design by a registered professional engineer, submit for information only and not for Engineer approval the following:

1. Copies of design calculations and notes for sloping, benching, support systems, shield systems, and other protective systems prepared by or under the supervision of a professional engineer legally authorized to practice in the jurisdiction where the Project is located.
2. Documents provided with evidence of registered professional engineer's seal, signature, and date in accordance with appropriate state licensing requirements.

PART 2 - PRODUCTS

2.01 GRANULAR PIPE EMBEDMENT:

A. Bedding Material: The bedding material for the pipelines shall consist of a well-graded mineral aggregate mixture which will provide good stability. The size range of the aggregate shall be from ½-inch minimum to 3/4-inch maximum, with a maximum amount of fines passing a No. 8 screen not to exceed 5-percent by weight and shall conform to ASTM C33, gradation size No. 67, Class B. That portion greater than 3/8-inch shall contain at least 50-percent of the particle having 3 or more fractured faces.

B. Bedding Material: Bedding material shall conform to the following limits when tested by means of laboratory sieves:

Per ASTM C33, Size No. 67	
Sieve Size	Percent Passing
¾ inch	90-100%
3/8 inch	20-55%
No. 4	0-10%
No. 8	0-5%

1. Gravel or crushed stone which shall not have a loss of more than 15% after five cycles when tested for soundness with sodium sulfate as described in AASHTO T104.

2.02 TRENCH STABILIZATION MATERIAL:

A. Material shall be one of the following:
   1. 2-inch minus river-run or pit-run gravel free from clay balls, roots and organic matter, graded from course to fine, with less than 8 percent by weight passing a ¼-inch sieve.
   2. As approved by the Owner and Engineer.

2.03 TRENCH BACKFILL:

A. Free from organic matter, refuse, ashes, cinders, frozen, or other unsuitable material.
B. Gravel, rock, or shale particle size shall not exceed 2 inches in greatest dimension.
C. Greater than 15% passing the No. 200 standard square-mesh sieve.

2.04 GENERAL TRENCH BACKFILL MATERIALS:

A. Obtain from the following:
   1. Trenches and other excavations included in this Contract.
   2. Borrow from location off Site.
   3. Combination of above.
B. Free from organic matter, refuse, ashes, cinders, frozen, or other unsuitable material.

C. Gravel, rock, or shale particle size limited as follows:
   1. Not to exceed 2 inches in greatest dimension within 12 inches of pipe or conduit.
   2. Gravel, rock, or shale not allowed within 12 inches of buried cable.
   3. Maximum dimension one-half the depth of layer to be compacted in other areas.

D. Contain sufficient fine materials to provide a dense mass free of voids and capable of satisfactory compaction.

E. Have moisture content enabling satisfactory placement and compaction.

F. Blended or otherwise processed to provide required gradation and obtain moisture content within the moisture content range of optimum or to 3% above optimum for cohesive materials, and within 2 points of optimum for granular materials. Optimum moisture and maximum as specified for pipe embedment as determined by ASTM D1557.

G. Use material as specified for pipe embedment, pipe zone fill, upper trench zone backfill, and trench stabilization.

PART 3 - EXECUTION

3.01 TRENCHING:

A. Equipment and Methods:
   1. Types of Equipment and methods may be at Contractor's option, where structures or other facilities are not endangered.
   2. Equipment and methods shall be subject to approval of jurisdictional agency where stability or usefulness of other facilities may be impaired.
   3. Perform by hand methods when required to save or protect trees, culverts, utilities, or other structures above or below ground.
   4. Maximum length of open trench shall be limited to 50 feet in advance and to 50 feet behind pipe installation, except as approved.

B. Side Walls:
   1. Make vertical or slope within specified trench-width limitations below a horizontal plane 12 inches above top of pipe.
   2. Vertical or sloped (stepped) as required for stability, above a horizontal plane 12 inches above top of pipe.
   3. Sheet and brace where necessary. Conform to applicable requirements of SECTION 31 20 00.
   4. Excavate without undercutting.

C. Trench Depth:
   1. Depth shall be sufficient to provide the minimum bedding requirements for the pipe being placed.
   2. Do not exceed the indicated depth where conditions of bottom are satisfactory.
   3. Increase depth as necessary to remove unsuitable supporting materials.

D. Trench Bottom:
   1. Protect and maintain when suitable natural materials are encountered.
   2. Remove rock fragments and materials disturbed during excavation or raveled from trench walls.
   3. Restore to proper subgrade with trench-stabilization material or timber mat topped with trench-stabilization material when overexcavated:
      a. Placement of Trench Stabilization Material:
         (1) Compact in lifts not exceeding 6-inch loose thickness:
            (a) With pneumatic or vibratory equipment.
            (b) To density specified for granular pipe embedment.

E. Trench Width:
   1. Excavate trench to a width which will permit satisfactory jointing of the pipe and thorough tamping of the bedding.
   2. Minimum and Maximum Trench Width:
      a. Maximum trench width shall not be more than 18-inches wider than the diameter of the pipe.
      b. Minimum trench width shall not be less than 12-inches wider than the diameter of the pipe.
      c. Maximum trench-width limitations shall apply beginning 4 feet from manhole or structure walls.
      d. Maximum width shall be as near the minimum specified as can be controlled by construction equipment and methods used.
      e. Correct when overexcavated at no additional cost to Owner:
         (1) Use stronger pipe or higher class embedment.

F. Trenching in Fill Areas: Perform trenching in fill areas only after compacted fill has reached an elevation of not less than 1 foot above the top of the pipe.

G. Test Pits:
   1. Excavate test pits sufficiently in advance of trenching to enable adequate planning of construction procedure.
   2. Locate as follows:
      a. Where unstable material is suspected that may require special protective measures.
      b. Where groundwater may require special handling methods.
      c. Where advisable to assess adequacy of blasting pattern.
      d. Where indicated or otherwise approved.
      e. Where interference or conflict with other utilities or structures could affect alignment of pipe.
   3. With lateral dimension not less than minimum trench width specified for location excavated.
   4. To depth required to obtain information desired.

3.02 PIPE EMBEDMENTS:

A. Granular Pipe Embedment:
   1. Place granular embedment as follows:
      a. Level bottom layer at proper grade to receive and uniformly support pipe barrel throughout its length.
      b. Form shallow depression under each joint to facilitate grouting.
      c. Form depression under each joint so that no part of bell or coupling is in contact with trench when pipe is placed in position.
      d. Add second layer simultaneously to both sides of the pipe with care to avoid displacement.
      e. Complete promptly after completion of jointing operationsand approval to proceed.
   2. Compact granular bedding as follows:
      a. In lifts not exceeding 12 inches in compacted depth.
      b. Rod, spade, or use pneumatic or vibratory equipment:
         (1) As required to obtain not less than 80% relative density as determined by ASTM Method D4253 and D4254.
         (2) Throughout depth of embedment.
         (3) Tamp, slice, and chink bedding under pipe haunches to completely fill all voids.

3.03 BACKFILLING:

A. Placement:
   1. Complete promptly after approval to proceed:
      a. Upon completion of pipe embedment.
   2. Use hand methods to a horizontal plane 12 inches above top of pipe- coupling, conduit, or duct banks.
   3. Use approved mechanical methods where hand backfill is not required.
   4. Place in layers of thickness within compacting ability of equipment used.
   5. Until compacted depth over conduit exceeds 3 feet, do not drop fill material over 5 feet. Then distance may be increased 2 feet for each additional 1 foot of cover. Backfill conduit trenches in layers of 4 to 8 inches.

B. Compaction:
   1. Perform with spreading equipment supplemented by hand-operated equipment and rollers as required to obtain density specified.
   2. Accomplish without inundation or flooding.
   3. Except as indicated otherwise, compact to 95% of maximum dry density within the moisture content range of -2% to 2% of optimum for granular material, and optimum to +3 points above optimum for clayey material. Optimum moisture and maximum density shall be as determined by ASTM D1557.
   4. Backfill failing to meet required densities shall be removed or scarified and recompacted as necessary to achieve specified results.

3.04 FIELD QUALITY CONTROL:

A. Compaction: Engineer will, through services of an Engineer selected laboratory paid for through the testing allowance, test all trench-stabilization material, granular pipe embedment, earth-pipe embedment, cut-off walls, and trench backfill to determine conformance with specified moisture- density relationships:
   1. Method of test will be as specified in SECTION 31 20 00.

B. Concrete: Contractor shall test all concrete for use in encasements, cradles, and concrete cut-off walls to determine conformance with Specifications. Method of test shall be as specified in DIVISION 3.

END OF SECTION 31 23 33

SECTION 31 63 29 – DRILLED SHAFT FOUNDATIONS

PART 1 - GENERAL

1.01 SUMMARY:

A. Work under this SECTION consists of furnishing all supervision, labor, equipment, materials, and quality control necessary to install all drilled shafts for the Thornton Wes Brown PAC silo.
B. Work under this SECTION shall conform to all requirements of ACI 336.1 published by the American Concrete Institute, Farmington Hills, Michigan, except as modified herein.
C. Drilled shafts shall be embedded to depths as indicated on the Drawings.
D. Contractor shall visit the Site prior to bidding to observe and review specific Site conditions and requirements for equipment, methods, and costs to install drilled shafts.
E. Contractor shall verify the location of all underground conduits, piping, duct banks and utilities prior to installing drilled shafts.
F. Owner will retain a Geotechnical Representative as defined herein.

1.02 RELATED REQUIREMENTS:

A. SECTION 03 30 50 – Concrete, Formwork, and Reinforcement

1.03 REFERENCE STANDARDS:

A. General:
   1. Standards listed by reference, including revisions by issuing authority, form a part of this SECTION to extent indicated. Standards listed are identified by issuing authority, authority abbreviation, designation number, title or other designation established by issuing authority. Standards subsequently referenced herein are referred to by issuing authority abbreviation and standard designation.
   2. Where specifications and reference documents conflict, the specification shall govern.
   3. Unless otherwise noted, the latest revision of the following reference standards shall apply to this SECTION.
B. Applicable Standards:
   1. American Concrete Institute (ACI):
      a. 336.1 - Specification for the Construction of Drilled Piers.
   2. American Petroleum Institute (API):
      a. 13A - Specification for Drilling-Fluid Materials.
   3. ASTM International (ASTM):
      a. D698 – Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3).
      b. D2487 – Classification of Soils for Engineering Purposes (Unified Soil Classification System).
      c. D4253 – Maximum Index Density of Soils Using a Vibratory Table.
      d. D4254 – Minimum Index Density of Soils and Calculation of Relative Density.

1.04 DEFINITIONS:

A. Geotechnical Representative – The Geotechnical Representative is responsible for observation and recording of material verification, drilled shaft installation sequence and methods, and other quality control documentation as specified herein.
B. Pumping of Concrete - Concrete placed under water or through slurry conveyed by pressure through a rigid pipe or flexible hose and discharged directly to bottom of shaft. Pressure is

applied by piston pumps, pneumatic compressed air, or squeeze pressure pumps in accordance with ACI 336.1. NOTE: Placement of concrete under water or through slurry will not be permitted during construction of drilled shafts which bear upon or are socketed into rock.

C. Rock Excavation – Intact rock material encountered in excavating drilled shafts which cannot be removed with a conventional earth auger, and which requires a rock auger, core barrel, or hand labor using air-powered tools and/or other special excavation procedures. Refusal of the earth auger shall be defined as a penetration rate equal to, or less than, 1 foot per 10-minute period with the full torque and crowd continuously applied. Earth, clay, coal seams, boulders, cobbles, rock fragments, soft fractured materials, or voids encountered between rock units will not be considered rock excavation.

D. Slurry - Method of advancing drilled shaft hole where bentonite (sodium montmorillonite in accordance with API 13A) or anionic polymer is mixed with clean water or water within shaft to produce a slurry mixture capable of maintaining the stability of shaft walls and bottom in potentially caving and/or water-bearing soils. Slurry is also used to increase density of fluid within shaft to offset exterior hydrostatic pressure and to facilitate removal of coarser grained soils by mixing and incorporation into the slurry mixture. NOTE: The use of slurry will not be permitted during construction of that portion of drilled shafts which bear upon or are socketed into rock.

E. Termination Criteria – All shafts shall be extended to the depths indicated.

F. Tremie - Concrete placed under water or through slurry by means of gravity flow through a rigid pipe. NOTE: The use of the tremie method of placing concrete will not be permitted. Pumping will be required when placing concrete under water or through slurry.

G. Unclassified Excavation - All materials encountered from the top of concrete or drilled shaft cutoff elevation to the tip-bearing elevation, exclusive of rock excavation as described above.

1.05 EXPERIENCE QUALIFICATIONS:

A. Drilled Shaft Contractor
   1. A minimum of five (5) years of experience in drilled shaft construction, including experience with similar subsurface materials, water conditions, shaft dimensions, and special techniques as required.
   2. Submit a written description of equipment and techniques proposed for use on this Contract, and the name of three (3) similar projects successfully completed in the last five (5) years.
   3. The experience statement of past work and description of equipment and techniques proposed for use shall be submitted at time of Bid and will be considered in the evaluation of bids.

B. All other guidelines for submitting information shall be followed in accordance with that specified in "INSTRUCTIONS TO BIDDERS."

1.06 SUBMITTALS:

A. Submit as specified in DIVISION 01.

B. Bid Submittals:
   1. Proposed drilled shaft rig name, model number, maximum continuous torque rating (ft-lb), maximum downward force ("crowd"), proposed earth and rock auger attachments, and proposed special techniques and equipment. Submittals shall reflect any Contractor modifications that affect the torque and crowd ratings.

2. Proposed method(s) of construction – dry and uncased, temporary casing, slurry, or other procedure. If slurry methods are proposed, indicate whether mineral and/or polymer slurry will be used.
3. Experience Qualifications.

C. Pre-Construction Submittals: Submit the following items two (2) weeks prior to start of Work. Work shall not begin until all the submittals have been received and approved by the Owner. The Contractor shall allow the Owner two (2) weeks to review, comment, and return the submittal package after a complete set has been received. All costs associated with incomplete or unacceptable submittals shall be the responsibility of the Contractor.
   1. Detailed procedures for each anticipated method of construction - dry and uncased, temporary casing, slurry, or other procedure including:
      a. Sequence of excavation, concrete placement, rebar cage placement, and placement of embedded items such as anchor bolts.
      b. Method of concrete placement (i.e., free-fall, pump, or other).
      c. Methods to prevent segregation of concrete during placement.
      d. Methods to prevent caving, if necessary.
      e. Equipment and procedures for removal of groundwater from within excavation.
      f. Equipment and procedures for cleanout of bottom of drilled shaft.
      g. Procedures for supporting rebar cage during concrete placement, including type, size and material construction of spacers to be used.
      h. Procedures for supporting anchor bolts or other embedded items (as applicable).
      i. Procedures for, and sequence of, installation and removal of temporary casing.
      j. Procedures for emergency cold joint construction in the event concrete placement is unexpectedly interrupted.
      k. Procedures for placement and mix design for controlled low strength material (CLSM) mix, as applicable to backfill rejected drilled shaft foundations.
   2. Backfill material and procedures.

D. Construction and Closeout Submittals:
   1. Drilled Shafts: Submit at the completion of each day, drilled shaft construction logs similar to the form at the end of this SECTION and which contain the following information, where applicable.
      a. Identification number.
      b. Shaft dimensions.
      c. Ground surface elevation.
      d. Bottom of concrete elevation.
      e. Top of concrete elevation.
      f. Description of soils and/or rock encountered during drilling and the depths at which transitions occur.
      g. A graph depicting the total volume of concrete and volume of concrete placed compared to theoretical concrete volume versus depth (only applicable to drilled shafts large enough to require multiple concrete trucks).
      h. Bearing stratum description.
      i. Nature and location of obstructions.
      j. Water conditions during drilling and concrete placement.
      k. Amount of unclassified excavation.
      l. Amount of rock excavation and length of socket, if required.
      m. Method of construction - dry and uncased, temporary casing, slurry, or other.
      n. Details on deep foundation integrity testing, if applicable.

2. As-built shaft location and elevation data.
3. Detailed description of any remediation performed to resolve non-conforming work as described herein.

PART 2 - PRODUCTS

2.01 CONCRETE:

A. As specified in SECTION 03 30 50, except as follows:
   1. Minimum compressive strength of 4500 psi at 28 days.
   2. Slump requirements for concrete placed in drilled shafts shall be based on the construction method used, as follows:
      a. For dry uncased excavations: 4 to 6 inches.
      b. For temporarily cased excavations: 6 to 8 inches.
      c. For slurry excavations or placement of concrete under water: 7 to 9 inches.

2.02 CONCRETE REINFORCEMENT:

A. As specified in SECTION 03 30 50.

2.03 CONCRETE FORMS:

A. As specified in SECTION 03 30 50.

2.04 SLURRY:

A. Slurry shall consist of a mixture of bentonite (sodium montmorillonite conforming to API 13A) or anionic polymer and water to produce a slurry of sufficient density to maintain stability of the shaft walls and bottom and to facilitate removal of coarser grained soils from the excavation.
B. Slurry shall be transported, premixed, and processed using equipment made specifically for these purposes. Mixing slurry within the foundation excavation is not permitted.
C. Slurry properties such as density, sand content, pH, viscosity, etc., shall be tested and maintained per manufacturer's recommended ranges through the duration of excavation.

2.05 CASING:

A. Temporary casing shall be steel and of sufficient strength to prevent collapse or cave-in of the excavation and prevent soil and water from entering the excavation during drilling, field observation, and concrete placement.

2.06 DRILLING EQUIPMENT:

A. Excavate drilled shafts with an auger rig capable of drilling, as a minimum, the diameter and depth of foundations, including sockets, as shown on the Drawings in the subsurface materials present. Contractor is responsible for selecting appropriate drilling equipment and procedures as required to install the drilled shafts as indicated and in the subsurface conditions present. Rock excavation should not be anticipated during drilling. Cobbles and/or boulders should not be anticipated during drilling. Other methods of excavation shall not be permitted.

PART 3 - EXECUTION

3.01 GENERAL EXCAVATION:

A. Unless otherwise approved in advance, construction of each drilled shaft shall be completed during one working day, including full excavation and placement of concrete.

B. Keep the ground surface for a minimum of 2 feet from the edge of the excavation clean and level.

C. Dispose of materials removed from the excavation at an off-site location unless otherwise directed.

D. Locate drilled shaft as indicated within the following tolerances. Deviations in excess of these tolerances shall be corrected at Contractor's expense, including additional costs for engineering, redesign, and inspection:
   1. Centerline: Within 3 inches or 4 percent of shaft diameter, whichever is less, of location indicated.
   2. Diameter: Plus 3 inches, minus 1 inch.
   3. Plumb: 1 percent of the length, 12.5 percent of shaft diameter, or 15 inches total, whichever is less.
   4. Cutoff Elevation: Plus 1 inch or minus 1 inch from cutoff elevation indicated.

E. Provide temporary casing with a minimum inside diameter equal to the nominal diameter of the drilled shaft and a sufficient strength to withstand the soil pressure. Provide casing on Site prior to start of excavation. At minimum, install temporary casing under the following conditions:
   1. To control seepage.
   2. To prevent collapse of the walls.

F. When casing is installed to control seepage or prevent collapse of the walls, casing shall be advanced in intimate contact with the surrounding soils and ahead of any excavation.

G. Casing shall not be permanently left in place.

H. Remove all material regardless of classification within the shaft to meet the termination criteria as defined herein. Geotechnical Representative will field observe the excavation or drilling spoils and determine whether the excavation has achieved the required termination criteria. If termination criteria has not been met, Contractor shall extend the excavation until the criteria has been met or shall contact the Owner for direction.

I. Excavate shaft bottom to a level plane. Cleanout and remove all loose material and spoil from sides and bottom of the shaft to the degree determined by the Geotechnical Representative, and prior to placing concrete. In no case shall the average thickness of sediments on the shaft bottom exceed one-half inch, with a maximum thickness of one inch. If concrete is not placed immediately after completion of excavation, re-auger base of excavation to remove loose materials prior to placing concrete.

J. Drilled shafts which are overexcavated without Geotechnical Representative's approval shall have the overexcavation filled with unreinforced concrete, provided shafts do not require reinforcing steel for lateral or uplift loadings at depth, at Contractor's expense. If loads on shaft require reinforcing steel, provide steel with adequate lap splice at Contractor's expense.

K. Take all precautions necessary to prevent blowouts and disturbance of the sides or bottom of the excavation. If required, maintain water or slurry in the shaft at all times at a height sufficient to produce a positive head in the shaft.

L. If loose soil, a high water table, or other condition which causes the sides or bottom of the excavation to be unstable is encountered, advance the excavation through use of slurry, a

temporary casing, or other approved method. The use of slurry shall be required for the construction of drilled shafts in cohesionless materials below the water table.

M. If water is encountered and fills up the excavation, continual removal of water via pumping must be done to prevent degradation of the soil after completion of excavation and prior to placement of concrete.

N. When slurry is used, maintain a positive head in the excavation at all times until placement of concrete. Circulate the slurry with sufficient consistency and velocity to remove the dislodged materials from the hole. Materials encountered which are too heavy to be removed by the slurry, may be removed by other approved means.

O. Mixing of slurry shall not be allowed in the drilled shaft excavation.

P. Selection of, use, and disposal of all slurry shall comply with contract documents and all applicable local, state, and federal requirements.

3.02 BACKFILLING:

A. Restore the ground surface to required grade in the lateral direction around the drilled shaft with on-site soils, to replace any soils that have collapsed or sloughed as a result of the Work.

B. Prior to any backfilling operations, submit proposed methods and materials for approval.

C. Placement and compaction of soils required to restore the ground surface to required grade shall be completed in accordance with the following:

1. Cohesive Soils:
   a. Materials include silts and clays generally exclusive of topsoil, sands and gravel. Materials for which impact compaction will produce a well-defined moisture-density relationship curve.
   b. Compaction shall achieve a minimum of 95 percent of maximum density with a moisture content plus or minus three (3) percent of optimum moisture per ASTM D698.
2. Cohesionless Soils:
   a. Materials include gravels, gravel-sand mixtures, sands, and gravelly sands exclusive of topsoil, clayey and silty materials. Materials which are free-draining and for which impact compaction will not produce a well-defined moisture-density relationship curve and for which the maximum density by impact methods will generally be less than by vibratory methods.
   b. Compaction shall achieve a minimum of 70 percent relative density as per ASTM D4253 and D4254.

3.03 CONCRETE FORMWORK:

A. As specified in SECTION 03 30 50.

B. Form the drilled shaft with round forms with an inside diameter equal to the drilled shaft's nominal diameter and of sufficient strength to restrain the concrete without deformation or settlement. Mushrooming at the top of the drilled shaft shall not be permitted.

C. Construct forms to be removable without marring concrete surface.

D. Surface of forms shall provide smooth, dense, plane surface to finished concrete where exposed to view.

E. Contractor shall be responsible for structural adequacy of formwork.

F. Do not remove forms and supports until at least 24 hours after completion of concrete placement (this period is a cumulative number of hours, not necessarily consecutive, during which the temperature of the concrete surface is above 50ºF).

3.04 CONCRETE STEEL REINFORCEMENT:

A. As specified in SECTION 03 30 50.
B. Unless otherwise indicated or approved, welding on concrete steel reinforcement is not permissible.
C. Wet setting of anchor bolts shall not be permitted.
D. Splice concrete steel reinforcement only as indicated.
E. Support or tie off the rebar cage to prevent downward movement.
F. Shall be fabricated as indicated prior to completion of excavation.
G. Provide spacers of sufficient quantity, design and material construction to maintain appropriate clearance from the side walls or casing and shaft bottom. Spacers shall be located at the top, bottom, and at every 10 feet vertical interval between. A minimum of one spacer per foot of shaft diameter shall be spaced equally around the perimeter of the reinforcing cage at each vertical interval.

3.05 CONCRETE PLACEMENT:

A. Wet forms with clear, potable water prior to placing concrete.
B. Prior to placement of concrete, center reinforcing cages in the drilled shaft excavation and suspend or tie them off in an approved manner to cutoff elevation.
C. Place concrete immediately after final inspection and approval by Geotechnical Representative.
D. Concrete not placed within 90 minutes from batch time shall be rejected.
E. Fill entire volume of drilled shaft with concrete to the cutoff elevation in one continuous operation. Cold joints and construction joints are not permitted unless otherwise indicated on the Contract Drawings. Complete concreting within the same working day in which drilled shaft is excavated. If concrete is not placed within 4 hours of completion of excavation, the bottom of the excavation shall be re-augured to remove any softened bearing material and re-inspected by the Geotechnical Representative.
F. Where practical, and without compromising the stability of the excavation, dewater excavation before placing concrete. Hold the water level in the bottom of the excavation prior to concreting at a nominal depth not to exceed 2 inches.
G. In dry excavations, place concrete with an approved drop pipe or funneling device. Approval of the funneling device shall be dependent upon Contractor's demonstrated ability to direct concrete flow so as not to fall or strike against the sides of the temporary casing, the sides of the drilled shaft excavation, or steel reinforcement before reaching the bottom. Use an extension pipe to limit the maximum concrete free-fall distance to 15 times the cage diameter, but no more than 60 feet.
H. Place concrete in a manner that will not cause segregation of the particles or permit infiltration of water or any other occurrence which would tend to decrease the strength of the concrete or the capacity of the finished drilled shaft.
I. Where dewatering to a depth of 2 inches or less is impractical, or when using the slurry method, place concrete under water or through slurry as follows:
    1. Use a rigid pipe or flexible hose. Displace the slurry mud or water as the concrete is placed. Keep the end of the pipe or hose embedded in the concrete as the concrete is placed.
    2. Should the end of the pipe or hose be accidently pulled out of the concrete during the placement, discontinue the placing immediately and withdraw the pipe or hose to the surface. Reseal the pipe or hose at its bottom. Reinsert pipe in the shaft with the sealed

end extending into the concrete to the level before the pullout. Placement may then be resumed.

3. Over pour the cutoff point shown on the Drawings. Dip out the excess concrete. Geotechnical Representative will then visually observe the concrete at the top of the pour. If any contamination of the concrete is observed, reinsert the pipe or hose a sufficient distance into the concrete and continue placing fresh concrete until the contaminated concrete has been replaced by uncontaminated concrete.
4. Draw off slurry displaced during concrete placement and remove from the Site.
5. Use of a tremie pipe, in lieu of pumping, shall not be permitted.

J. Do not disturb the temporary casing, until a sufficient depth of concrete has been placed in the shaft excavation such that no voids will occur in the shaft due to intrusion of soil or water as the temporary casing is being withdrawn. If a known void is present along the sides of the drilled shaft, sufficient concrete shall be placed prior to disturbing the temporary casing such that sufficient concrete will remain above the bottom of casing after the void is passed.

K. Coordinate the withdrawal of temporary casing with concrete placement to maintain a minimum concrete head of five (5) feet above the casing bottom or until a sufficient depth of concrete has been placed to prevent intrusion of soil or water into the shaft concrete as the temporary casing is being withdrawn. Keep the temporary casing plumb and withdraw with a smooth, vertical motion, without jerks.

L. Should soil, rock, or water enter the excavation and contaminate the concrete, remove the contaminated concrete before completing pour.

M. Place concrete in accordance with applicable practices recommended by ACI.

N. Conveying:
1. Convey concrete from the mixer and deposit in place by methods which will prevent the segregation or loss of materials.
2. Equipment for chuting, pumping, and pneumatically conveying concrete shall be of such size and design as to provide a practically continuous flow of concrete at the delivery end.
3. Do not use aluminum conveying equipment.

O. Consolidation of Concrete:
1. Provide an adequate number of vibrators of sufficient capacity to keep up with the maximum rate of concrete placement. Keep on hand adequate standby equipment in good operating condition.
2. Vibrate concrete within the top 5 feet, only after temporary casing has been pulled or when casing is permanent.
3. Vibrate concrete until the concrete is thoroughly consolidated and the voids filled as evidenced by the level appearance of the concrete at the exposed surface and the embedment of the surface aggregate. Do not over vibrate to avoid segregation of concrete aggregate from the cement paste.

P. Additionally, as specified in SECTION 03 30 50.

3.06 NON-CONFORMING WORK:

A. Contractor shall be solely responsible for full compliance with the Contract Documents regardless of if and when discrepancies are brought to their attention. Contractor shall be responsible for all re-work necessary to achieve full compliance with the Contract Documents. Repairs or replacement shall be at the sole expense of the Contractor, including the costs to redesign, as required.

B. Owner may employ one or more of their representatives for observation and testing services.

C. Owner or Geotechnical Representative may reject any shafts which, in their opinion, do not conform to the Contract Documents or are shown to be deficient based on deep foundation integrity testing.

D. As directed by Owner, perform the following for rejected shafts at no additional cost to Owner:
   1. Leave shafts in place, cut off as directed, and install one or more replacement shafts in designated location(s).
   2. Withdraw the shaft and install a new shaft in the same location.
   3. Any holes which result from shaft withdrawal or excavation that results in unstable excavation shall be backfilled with controlled low strength material (CLSM) with strength characteristics equal to or greater than the material excavated. Contractor shall provide documentation of proposed CLSM mix planned for use.
   4. Pressure grouting to fill voids or restore sidewall or base soil conditions that have been disturbed due to the Work.
   5. Other remediation work, as directed.

END OF SECTION 31 63 29

Owner _____

Project Name _____

Project No. _____

Contract No. _____

Single Shaft

Record Report

Shaft No. _____

AS DESIGNED (Per Drawings)

Shaft Location/Area _____

Type/Diameter _____

Top Elevation (ft) _____

Length (ft) _____

Rebar Length (ft) _____

AS CONSTRUCTED

Started _____

Date/Time Completed _____

Diameter _____

Top Elevation (ft) _____

Bottom Elevation (ft) _____

Length (ft) _____

Tolerance _____

Plumbness _____

Concrete, Cy _____

Concrete Mix ID _____

Rebar Length _____

Socket Length (ft) _____

REMARKS

Bearing Material Description _____

_____

_____

Rebar - Size & Condition _____

_____

_____

Notes _____

_____

_____

_____

_____

_____

_____

_____

Shaft Log *(INCLUDE: Ground Elevations, Size, Shaft Casing, Water Conditions, Drilling & Concreting, Nature & Location of Obstructions, & All Other Pertinent Information.)*

Elevation: _____

Elevation: _____

Time of Concrete

Placement Start _____

Finish _____

_____

Drilled Shaft Subcontractor

_____

General Contractor

_____

Observer Name & Company

DIVISION 32 – EXTERIOR IMPROVEMENTS

SECTION 32 11 23 - CRUSHED AGGREGATE BASE COURSE

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and DIVISION 01 Specification Sections, apply to this Section.

1.02 SUMMARY:

A. This Section consists of a base course composed of crushed aggregates constructed on a prepared course in accordance with these Specifications and in conformity to the dimensions and typical cross-sections shown on the Plans.

1.03 RELATED REQUIREMENTS:

A. Section 31 20 00 - Site Preparation and Earthwork.

1.04 REFERENCE STANDARDS:

A. The publications listed below form a part of this Specification to the extent referenced. The publications are referred to within the text by the basic designation only.
   1. ASTM International (ASTM):
      a. ASTM C29 - Unit Weight of Aggregate.
      b. ASTM C88 - Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
      c. ASTM C117 - Materials Finer than No. 200 Sieve in Mineral Aggregates by Washing.
      d. ASTM C131 - Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
      e. ASTM C136 - Sieve Analysis of Fine and Coarse Aggregates.
      f. ASTM D75 - Sampling Aggregate.
      g. ASTM D422 - Particle Size Analysis of Soils.
      h. ASTM D693 - Crushed Aggregate for Macadam Pavements.
      i. ASTM D698 - Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5-lb. Rammer and 12-inch Drop.
      j. ASTM D1556 - Density of Soil in Place by the Sand-Cone Method.
      k. ASTM D1557 - Test for Laboratory Compaction Characteristics of Soil Using Modified Effort.
      l. ASTM D2167 - Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
      m. ASTM D2419 - Sand Equivalent Value of Soils and Fine Aggregate.
      n. ASTM D6938 - In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods.
      o. ASTM D3665 - Random Sampling of Construction Materials.
      p. ASTM D4318 - Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
   2. State of Colorado Department of Transportation (CDOT) Standard Specifications for Road and Bridge Construction.

1.05 SUBMITTALS:

A. Submit the following in accordance with DIVISION 01.
   1. Product Data:
      a. Sieve analysis.
      b. Aggregate sources.
   2. Test Reports.

1.06 QUALITY ASSURANCE:

A. Equipment Approval:
   1. All plant, equipment, and tools used in the performance of the Work will be subject to approval before the Work is started and shall be maintained in satisfactory working condition at all times. Submit a list of proposed equipment, including descriptive data. Provide adequate equipment having the capability of producing the required compaction, meeting grade controls, thickness control, and smoothness requirements as set forth herein.

B. Sampling and Testing:
   1. Tests to determine conformance with all requirements of this Specification for quality and properties of all Contractor-secured sources of materials shall be performed by an independent commercial laboratory retained and compensated by Contractor and approved by Engineer. In lieu of testing, Contractor may submit certified state test results indicating the aggregate meets Specification requirements to Engineer for approval.
   2. Obtain representative samples of material in accordance with ASTM D75/D75M for testing. Furnish laboratory sufficient material for testing from each sample at the time obtained. Copies of reports and certificates regarding tests and inspection of materials shall be distributed as specified in DIVISION 1. Furnish specific schedule for sampling to provide Engineer the opportunity to observe sampling.
   3. When incorporating materials into the Work, quality control testing will be performed during construction by a testing laboratory retained and compensated by Owner.
   4. Sampling:
      a. Take samples for laboratory testing in conformance with ASTM D75/D75M. When deemed necessary, the sampling will be observed by the Engineer.
   5. Tests:
      a. Perform the following tests in conformance with the applicable standards listed.
      b. Sieve Analysis:
         (1) Make sieve analysis in conformance with ASTM C117 and ASTM C136. Sieves shall conform to ASTM E11. Particle-size analysis of the soils shall also be completed in conformance with ASTM D422.
      c. Liquid Limit and Plasticity Index:
         (1) Determine liquid limit and plasticity index in accordance with ASTM D4318.
      d. Moisture-Density Determinations:
         (1) Determine the laboratory maximum dry density and optimum moisture content in accordance with ASTM D1557 or AASHTO T 180, Method D and corrected with AASHTO T 224.
      e. Field Density Tests:
         (1) Measure field density in accordance with ASTM D1556, ASTM D2167, or ASTM D6938.
            (a) Submit certified copies of test results for approval not less than 30 days before material is required for the Work.

(b) Submit calibration curves and related test results prior to using the device or equipment being calibrated.
(c) Submit copies of field test results within 24 hours after the tests are performed.

f. Wear Test:
(1) Perform wear tests on aggregate base course material in conformance with ASTM C131.

g. Soundness:
(1) Perform soundness tests on GCA in accordance with ASTM C88.

1.07 ENVIRONMENTAL REQUIREMENTS:

A. Perform construction when the atmospheric temperature is above 35ºF. When the temperature falls below 35ºF, protect all completed areas by approved methods against detrimental effects of freezing. Correct completed areas damaged by freezing, rainfall, or other weather conditions to meet specified requirements.

PART 2 - PRODUCTS

2.01 GENERAL:

A. Crushed rock base and surface course shall consist of aggregate specified.

2.02 AGGREGATE:

A. Aggregate shall be crushed stone or crushed gravel, free from lumps or balls of clay, dirt, silt, vegetable matter, or other objectionable matter and reasonably free from thin and elongated pieces of aggregate. Aggregates shall consist of angular fragments, durable and sound, and shall be reasonably uniform in density and quality. Fine aggregate passing the No. 4 sieve shall consist of fines from the operation of crushing the coarse aggregate. If necessary, fine aggregate may be added to produce the correct gradation. The fine aggregate shall be produced by crushing stone, gravel, or slag that meet the requirements for wear and soundness specified for coarse aggregate.

B. Percentage of wear shall not exceed 45% when tested in accordance with ASTM C131. The sodium sulfate soundness loss shall not exceed 12% after 5 cycles when tested in accordance with ASTM C88.

C. Portion of aggregate which is retained on a 3/8-inch sieve shall contain 75% by weight of pieces with two or more fractured surfaces if the material is crushed gravel.

D. Portion of aggregate passing No. 40 sieve shall be as follows:
1. Liquid Limit: Not more than 25 determined by ASTM D4318.
2. Plastic Index: Not more than 4 determined by ASTM D4318.
3. The fine aggregate shall have a minimum sand equivalent value of 35 when tested in accordance with ASTM D2419.

E. Aggregate Surface Course:
1. Gradation shall not vary from low limit on one sieve to high limit on adjacent sieve or vice versa. Aggregate for gravel surfacing shall match gradation below, unless otherwise approved by Engineer.

Sieve Size	Percent Passing
3 inch	100%

3/4 inch	20-90%
No. 4	0-20%
No. 200	0-3%

F. Aggregate Base Course:
1. Gradation shall not vary from low limit on one sieve to high limit on adjacent sieve or vice versa. Aggregate for Base Course shall be Class 6 Aggregate Base Course as specified in CDOT Standard Specifications.

Sieve Size	Percent Passing
3/4 inch	100%
No. 4	30-65%
No. 8	25-55%
No. 200	3-12%

PART 3 - EXECUTION

3.01 PREPARING UNDERLYING COURSE:

A. The underlying course shall be checked and accepted by the Engineer before placing and spreading operations are started. Any ruts or soft yielding places caused by improper drainage conditions, hauling, or any other cause shall be corrected at the Contractor's expense before the base course is placed thereon. Material shall not be placed on frozen subgrade.

3.02 MIXING:

A. The aggregate shall be uniformly blended during crushing operations or mixed in a plant. The plant shall blend and mix the materials to meet the Specifications and to secure the proper moisture content for compaction.

3.03 PLACING:

A. The crushed aggregate base material shall be placed on the moistened subgrade in layers of uniform thickness with a mechanical spreader.
B. The maximum depth of a compacted layer shall be 6 inches. If the total depth of the compacted material is more than 6 inches, it shall be constructed in two or more layers. In multi-layer construction, the base course shall be placed in approximately equal-depth layers.
C. The previously constructed layer should be cleaned of loose and foreign material prior to placing the next layer. The surface of the compacted material shall be kept moist until covered with the next layer.

3.04 COMPACTION:

A. Immediately upon completion of the spreading operations, the crushed aggregate shall be thoroughly compacted. The number, type, and weight of rollers shall be sufficient to compact the material to the required density.
B. The moisture content of aggregate material during placing operations shall not be more than -2 percentage point below, or more than 2 percentage points above, the optimum moisture content as determined by ASTM D698.

3.05 ACCEPTANCE SAMPLING AND TESTING FOR DENSITY:

A. Aggregate base course shall be accepted for density on a lot basis. A lot will consist of one day's production where it is not expected to exceed 2,400 sq. yds. A lot will consist of one-half

day's production where a day's production is expected to consist of between 2,400 and 4,800 sq. yds.

B. Each lot shall be divided into two equal sublots. One test shall be made for each sublot. Sampling locations will be determined by a random basis in accordance with statistical procedures contained in ASTM D3665.

C. Each lot will be accepted for density when the field density is at least 95% of the maximum density of laboratory specimens prepared from samples of the base course material delivered to the Job Site. The specimens shall be compacted and tested in accordance with ASTM D1557. The in-place field density shall be determined in accordance with ASTM D1556 or D2167. If the specified density is not attained, the entire lot shall be reworked and/or recompacted and two additional random tests made. This procedure shall be followed until the specified density is reached.

D. In lieu of the core method of field density determination, acceptance testing may be accomplished using a nuclear gauge in accordance with ASTM D6938. The gauge should be field calibrated in accordance with and ASTM Standards. Calibration tests shall be conducted on the first lot of material placed that meets the density requirements.

E. When using the nuclear method ASTM D6938 shall be used to determine the moisture content of the material. The calibration curve furnished with the nuclear gauges shall be checked in accordance with ASTM standards. The calibration checks shall be made at the beginning of a job and at regular intervals.

F. If a nuclear gauge is used for density determination, two random readings shall be made and averaged for each sublot.

3.06 FINISHING:

A. The surface of the aggregate base course shall be finished by blading or with automated equipment especially designed for this purpose.

B. In no case will the addition of thin layers of material be added to the top layer of base course to meet grade. If the elevation of the top layer is 1/2 inch or more below grade, the top layer of base shall be scarified to a depth of at least 3 inches, new material added, and the layer shall be blended and recompacted to bring it to grade. If the finished surface is above plan grade, it shall be cut back to grade and rerolled.

3.07 SURFACE TOLERANCES:

A. The finished surface shall not vary more than 3/8 inch when tested with a 16-foot straightedge applied parallel with or at right angles to the centerline. Any deviation in excess of this amount shall be corrected by the Contractor at the Contractor's expense.

3.08 THICKNESS CONTROL:

A. The completed thickness of the base course shall be within 1/2 inch of the design thickness. Four determinations of thickness shall be made for each lot of material placed. The lot size shall be consistent with that specified in Paragraph 3.05. Each lot shall be divided into four equal sublots. One test shall be made for each sublot. Sampling locations will be determined by a random basis in accordance with procedures contained in ASTM D3665. Where the thickness is deficient by more than 1/2 inch, the Contractor shall correct such areas at no additional cost by excavating to the required depth and replacing with new material. Additional test holes may be required to identify the limits of deficient areas.

3.09 MAINTENANCE:

A. The base course shall be maintained in a condition that will meet all specification requirements until the Work is accepted. Equipment used in the construction of an adjoining section may be routed over completed portions of the base course, provided no damage results and provided that the equipment is routed over the full width of the base course to avoid rutting or uneven compaction.

B. The Contractor shall remove all survey and grade hubs from the base courses prior to placing any bituminous surface course.

END OF SECTION 32 11 23

SECTION 32 12 16 – ASPHALT PAVING

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes hot mix asphalt pavement for roads, drives, and parking areas.
B. Asphalt paving per City of Thornton Standard Section 504.
C. Related Work Specified Elsewhere:
   1. Trenching and Backfilling for Utilities: SECTION 31 23 33.
   2. Crushed Aggregate Base Course: SECTION 32 11 23

1.02 REFERENCES:

A. Applicable Standards:
   1. American Society for Testing and Materials (ASTM):
      a. C29/C29M - Test Method for Unit Weight and Voids in Aggregate.
      b. C117 - Test Method for Material Finer than No. 200 Sieve in Mineral Aggregates by Washing.
      c. C127 - Test Method for Specific Gravity and Absorption of Coarse Aggregate.
      d. C128 - Test Method for Specific Gravity and Absorption of Fine Aggregate.
      e. C131 - Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
      f. C136 - Method for Sieve Analysis of Fine and Coarse Aggregates.
      g. D75 - Practices for Sampling Aggregates.
      h. D140 - Practice for Sampling Bituminous Materials.
      i. D1557 – Test Method for Laboratory Compation Characteristics of Soil Using Modified Effort 56,000 ft-lbf/ft^3.
      j. D2950 - Test Method for Density of Bituminous Concrete in Place by Nuclear Method.
   2. American Association of State Highway and Transportation Officials (AASHTO):
      a. M140 – Emulsified Asphalt
      b. M208 – Cationic Emulsified Asphalt
      c. M320 – Standard Specification for Performance-Graded Asphalt Binder
      d. T230 – Density of Bituminous Aggregate Mixtures
   3. State of Colorado Department of Transportation (CDOT) Standard Specifications for Road and Bridge Construction.
   4. The subsurface exploration and geotechnical engineering report named "*Geotechnical Engineering Study and Pavement Thickness Design Proposed Wes Brown Wastewater Treatment Plant Silo and Equipment Building 3651 East 86th Avenue Thornton, Colorado*", by Kumar & Associates, Inc., dated October 23, 2025.
   5. City of Thornton Standards and Specifications for the Design and Construction of Public and Private Improvements, current edition.

1.03 SUBMITTALS:

A. Submit required documents for information or approval as described in SECTION 01 33 00-SUBMITTALS.

1.04 TESTING:

A. Completed pavement will be tested to determine density, gradation, and asphalt content (by extraction) without charge to Contractor:
   1. At Contractor's option, density may be tested by any of the following methods:

a. AASHTO T230
b. ASTM D2950.

B. Contractor shall perform such other tests as Contractor deems necessary to assure production of hot mix asphalt conforming to specified quality.

C. Contractor shall test surface smoothness by applying a 10-foot straightedge both parallel and at right angles to the centerline of paved areas:
1. Test at 50-foot maximum intervals, and more frequently when requested by Contractor.
2. Contractor will observe straightedge testing.

1.05 TOLERANCES:

A. Density of completed pavement shall be not less than the following percentage of the density of the laboratory mix design:
1. First Lift of Base Course: 95%.
2. All Other Courses: 95%.

B. Surface:
1. Surface shall be of uniform texture and appearance.
2. Smoothness shall be such that variation from a 10-foot straightedge does not exceed the following limits:
a. Final Lift of Base Course: 1/2-inch.
b. Surface Course: 3/8-inch.

PART 2 - PRODUCTS

2.01 GENERAL

A. Equipment and Materials shall conform to the requirements of the State of Colorado Department of Transportation (CDOT) Standard Specifications for Road and Bridge Construction.

2.02 MATERIAL

A. Bituminous Material:
1. Asphalt Cement:

	WBWTP Roads
Final (Top) Course	PG 64-22
Bottom Courses	PG 64-22

1. Reclaimed asphalt pavements (RAP):
a. Mixes shall NOT contain more than 15% recycled or reclaimed asphalt pavements (RAP) in the mix.
2. Tack Coat: Any of the following liquid asphalts at Contractor's option:
a. SS-1h; Emulsified asphalt conforming to AASHTO M140.
b. Emulsified asphalt shall be diluted 1:1 with water

B. Asphaltic Concrete Mixture:
1. Mixtures:

a. Bottom Courses: Hot bituminous pavement Grading S.
b. Top Course: Hot bituminous pavement Grading SX.

2. Superpave gyratory design revolutions: N(des) = 75
3. Design air voids = 3.5% to 4.5%, target of 4.0%
4. At least 60% of the aggregate retained on the No. 4 sieve shall have at least two mechanically induced fractured faces.
5. Minimum Voids in the Mineral Aggregate (VMA) shall be according to the following table (interpolate values as needed):

Nominal Maximum Size	Design Air Voids		
	3.5%	4.0%	4.5%
1-1/2	11.6	11.7	11.8
1	12.6	12.7	12.8
3/4	13.6	13.7	13.8
1/2	14.6	14.7	14.8
3/8	15.6	15.7	15.8

6. Voids Filled with Asphalt (VFA) shall be minimum 65% to 80%.
7. Minimum Hveem Stability shall be 28.

PART 3 - EXECUTION

3.01 GENERAL:

A. Performance shall conform to the requirements of the State of Colorado Department of Transportation (CDOT) Standard Specifications for Road and Bridge Construction and City of Thornton Standards and Specifications.
B. Areas to be patched shall be excavated and squared to a neat line, leaving the sides of the excavation vertical. Prior to placement of the patch the exposed sides of the existing pavement shall be thoroughly coated with Emulsified Asphalt (slow-setting). Hot mix asphalt shall then be placed and compacted in succeeding layers not to exceed 3 inches in depth.
C. Contractor shall limit the amount of asphalt placed by hand.
   1. A paving machine shall be used when trench patchback limit exceeds fifty (50) linear feet.

3.02 TACK COAT:

A. Apply tack coat to the surface of all existing pavement and all previously placed hot mix asphalt lifts or courses before placing the succeeding lift.
B. Apply at the following rates:
   1. Emulsified Asphalt: five one-hundredths (0.05) to fifteen one-hundredths (0.15) gallons per square yard.

3.03 BASE COURSE:

A. Place according to Part 1 and to the dimensions shown on the drawings.

END OF SECTION 32 12 16

DIVISION 33 - UTILITIES

SECTION 33 30 00 – GRAVITY PIPE
PART 1 - GENERAL

1.01 SUMMARY:
- A. This Section includes all gravity pipe, fittings and specials.
- B. Related Work Specified Elsewhere:
  1. Utility Structures: SECTION 33 39 00.
  2. Pipe Installation: SECTION 33 31 50.

1.02 REFERENCES:
- A. Applicable Standards:
  1. American Society for Testing and Materials (ASTM):
     a. D3034 - Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
     b. D3212 - Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
     c. F477 - Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
     d. F679 - Poly(Vinyl Chloride) (PVC) Large - Diameter Plastic Gravity Sewer Pipe and Fittings.
  2. American Water Works Association (AWWA):
     a. C115 - Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges.

1.03 SUBMITTALS:
- A. Submit as specified in DIVISION 1- GENERAL REQUIREMENTS.
- B. Submit the following for acceptance prior to fabrication:
  1. Pipe and joint details.
  2. Special, fitting and coupling details.
  3. Laying and installation schedule.
- C. Certificates and Affidavits:
  1. Submit as specified in DIVISION 1 - GENERAL REQUIREMENTS.
  2. Furnish the following prior to shipment:
     a. Affidavit of compliance with applicable standard.
     b. Test certificates.

1.04 QUALITY ASSURANCE:
- A. Manufacturer:
  1. Experienced in the design, manufacture and commercial supplying of the specific material for a minimum period of five years.
  2. Experienced in the design, manufacture, and commercial supplying of the specific size of pipe for a minimum period of three years.
  3. Certify to above minimum experience requirements.

1.05 DELIVERY, STORAGE AND HANDLING:
- A. Ship all material to the Site and store in assigned laydown areas or as directed by Contractor.
- B. Ship spare material separately packaged and tagged as spare parts. Spare part tags shall identify type, size, material, and other related information.
- C. Handling and storage shall be in accordance specification requirements.

PART 2 - PRODUCTS

2.01 PIPE REQUIREMENTS:

A. Furnish pipe of materials, joint types, sizes, and strength classes indicated or specified. Higher strengths may be furnished at Subcontractor's option. Furnish maximum pipe lengths produced by the manufacturer.

B. Pipe Bedding: As specified and as indicated.

C. Pipe Marking:
   1. All pipe, fittings and specials shall be marked conforming to the applicable standard specification under which the pipe is manufactured and as otherwise specified.
   2. Mark field location of fittings and specials by station.

D. Pipe Gaskets: All elastomeric gaskets and seals shall be synthetic rubber.

2.02 PVC SEWER PIPE:

A. Materials and Manufacture: Conform to ASTM D3034 and ASTM F679 for pipes with smooth interior and exterior. All PVC piping shall be as specified and modified herein.
   1. Pipe 15-inch and smaller: Shall be Polyvinyl Chloride (PVC) pipe conforming to ASTM D3034 with a minimum wall thickness of SDR-35.
   2. Pipe 15-inch and larger: Shall be Polyvinyl Chloride (PVC) pipe conforming to ASTM F679 with a minimum pipe stiffness of 45 psi (PS 46).
   3. Minimum pipe stiffness, when measured at 5% deflection, shall be as follows:
      a. 310 kPa (45 psi) for ASTM D3034 and ASTM F679 pipes.
   4. Joints:
      a. Compression-type with the elastomeric ring gasket confined in the annular space between the bell end or socket and the spigot end of pipe.
      b. Elastomeric gasket ring joints shall conform to the requirements of ASTM D3212 or ASTM F477. Gaskets shall be neoprene or other synthetic rubber material.
      c. Plain end of pipe shall be marked with a reference line to facilitate assembly inspection.
   5. Fittings: Tee or wye connections suitable for assembly to 100 mm (4-inch) or 150 mm (6-inch) house or building sewers shall be one of the following types.
      a. Reducing-branch tee or wye fittings with elastomeric-gasket joints same as pipe. Service line connection shall be bell-end with an elastomeric ring-gasket and a minimum wall thickness of SDR35.
      b. Saddle-type fittings with an elastomeric ring-gasketed bell-end service connection and minimum wall thickness of SDR35. Saddle-type fitting to be supplied with a rubber sealing gasket and stainless steel straps for connection to pipe.
      c. Furnish permanent plugs for future service line connections and testing.
   6. Connections: Furnish any special flexible couplings required for manhole tie-ins or connections to other rigid structures.

B. Inspection and Testing:
   1. Primarily by manufacturer's testing laboratory and quality control personnel.
   2. Perform to avoid, insofar as possible, delivery of defective pipe.
   3. May be witnessed by Contractor, or approved independent testing laboratory.
      a. Independent testing laboratory, when used, shall be retained by Contractor.
      b. Subcontractor and manufacturer shall cooperate with Contractor's inspection and test personnel. Permit unrestricted access, furnish reasonable space and facilities, and provide 5 working days advance notice of test schedule.
   4. Subcontractor shall provide 3 copies each of certified test reports to Contractor.

a. Include stiffness and deflection, dimension, and hydrostatic joint tests per ASTM D3034, D3212, and F679.
b. Furnish prior to delivery.

C. Handling and Delivery:
1. Do not deliver until tests on representative specimens have been performed.
2. Use equipment and methods adequate to preserve quality of pipe and to protect joint elements.

D. Identification: Green metallic lined plastic underground warning tape shall be buried approximately 2-1/2 feet below grade and a minimum of 12 inches directly above pipe with printed caption in block letters "CAUTION-SANITARY SEWER".

2.03 GASKET MATERIALS:

A. Provide all gaskets lubricant and other accessories required to install pipe, fittings and specials complete and ready for service.

B. Gaskets for flanged joints shall conform to AWWA C115, 3 mm (1/8-inch)-thick, full-face synthetic rubber.

PART 3 - EXECUTION

3.01 INSTALLATION: Specified in SECTION 33 31 50.

3.02 FIELD TESTING: Specified in SECTION 33 31 50.

END OF SECTION 33 30 00

SECTION 33 31 50 - PIPE INSTALLATION

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes handling, installation and testing of steel, DIP, PVC, HDPE, stainless steel pipe, fittings, specials, and appurtenances as indicated or specified.

B. Related Work Specified Elsewhere:

1. SECTION 33 30 00 – Gravity Pipe

1.02 REFERENCES:

A. Applicable Standards:

1. City of Thornton Standards and Specifications:
   a. Section 200 Water System Standards.
   b. Section 300 Sanitary Sewer System Standards.
2. American Association of State Highway and Transportation Officials (AASHTO).
3. American Water Works Association (AWWA):
   a. C104 - Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
   b. C110 - Ductile-Iron and Gray-Iron Fittings.
   c. C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   d. C115 - Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
   e. C116 – Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings.
   f. C150 - Thickness Design of Ductile-Iron Pipe.
   g. C151 - Ductile-Iron Pipe, Centrifugally Cast, for Water.
   h. C153 - Ductile-Iron Compact Fittings.
   i. C200 - Steel Water Pipe 6 Inches (150 mm) and Larger.
   j. C205 - Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 Inch and Larger - Shop Applied.
   k. C206 - Field Welding of Steel Water Pipe.
   l. C207 - Steel Pipe Flanges for Waterworks Service, Sizes 4 Inch Through 144 Inch.
   m. C208 - Dimensions for Fabricated Steel Water Pipe Fittings.
   n. C209 - Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.
   o. C210 - Liquid-Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
   p. C213 - Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
   q. C214 - Tape Coating Systems for Steel Water Pipe.
   r. C219 - Bolted, Sleeve-Type Couplings for Plain-End Pipe.
   s. C600 - Installation of Ductile-Iron Water Mains and Their Appurtenances.
   t. C651- Disinfecting Water Mains.
   u. C900 – Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 Inch through 60 Inch.
   v. M11 - Steel Pipe - A Guide for Design and Installation.
   w. M23 – PVC Pipe-Design and Installation.
   x. M41 - Ductile-Iron Pipe Fittings.
   y. C906 – Polyethylene (PE) Pressure Pipe & Tubing, 4-Inch Through 63-Inch for Waterworks.
   z. M55 – Manual for the Design and Installation of Polyethylene Pipe in water Applications.
4. American National Standards Institute (ANSI):

a. B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
b. B16.5 – Pipe Flanges and Flanged Fittings.
c. B16.9 - Factory-Made Wrought Steel Buttwelding Fittings.
d. B16.21 - Nonmetallic Flat Gaskets for Pipe Flanges.

5. American Society for Testing and Materials (ASTM):
   a. A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60000 PSI Tensile Strength.
   b. A530 – Standard Specification for General Requirements for Specialized Carbon and Alloy Steel Pipe.
   c. G62 - Standard Test Methods for Holiday Detection in Pipeline Coatings.
   d. F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
   e. F593 – Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
   f. F594 – Standard Specification for Stainless Steel Nuts.
   g. D638 – Standard Test Method for Tensile Properties of Plastics.
   h. D2122 – Standard Method of Determining Dimensions of Thermoplastics Pipe and Fittings.
   i. D2290 – Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic Pipe.
   j. D2683 – Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing.
   k. D2774 – Standard Practice for Underground Installation of Thermoplastic Pressure Piping
   l. D2837 – Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials.
   m. D3035 – Standard Specification for Polyethylene Plastic Pipe Based on Controlled Outside Diameter.
   n. D3261 - Standard Specification for Butt Heat Fusion
   o. D3035 – Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Controlled Outside Diameter.
   p. E3261 – Standard Specification for Butt Heat Fusion Polyethylene Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
   q. D3350 – Standard Specification for PE Pipe & Fittings Material.
   r. F412 – Standard Terminology Relating to Plastic Piping Systems.
   s. F714 – Standard Specification for PE Pipe (SDR-PR) Based on Outside Diameter.
   t. F905 – Standard Practice for Qualification of Polyethylene Saddle-Fused Joints
   u. F1055 – Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing.
   v. F2164 – Standard Practice for Field Leak Testing of Polyethylene (PE) and Crosslinked Polyethylene (PEX) Pressure Piping Systems Using Hydrostatic Pressure
   w. F2206 – Standard Specification for Fabricated Fittings of Butt-Fused Polyethylene.
   x. F2620 – Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings.
6. American Welding Society (AWS).
7. International Organization for Standardization (ISO).
8. National Sanitation Foundation (NSF):
   a. NSF 61 - Drinking Water System Components - Health Effects.
   b. Techniques – Dimensions, Technical Requirements and Testing.

9. Society for Protective Coatings (SSPC):
    a. SP1 - Solvent Cleaning.
    b. SP3 - Power Tool Cleaning.
    c. SP5 - White Metal Blast Cleaning.
    d. SP7 - Brush-Off Blast Cleaning.
    e. SP10 - Near-White Blast Cleaning.
10. Plastic Pipes Institute (PPI):
    a. Handbook of Polyethylene Pipe.
    b. MS-3 – HDPE Pipe and Fittings Specification for Buried Potable Water.
    c. TR-3 – Policies and Procedures for Developing Hydrostatic Design Basis (HDB), Pressure Design Basis (PDB), Strength Design Basis (SDB), and minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe.
    d. TR-4 - HDB/SDB/PDB/MRS Listed Materials, PPI Listing of Hydrostatic Design Basis (HDB), Strength Design Basis (SDB), Pressure Design Basis (PDB), and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe.
    e. TR-9 – Recommended Design Factors for Pressure Applications of Thermoplastic Pressure Pipe Materials.
    f. TR-33 – Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe.
    g. TN-42 – Recommended Minimum Training Guidelines for PE Pipe Butt Fusion Joining Operators for Municipal and Industrial Projects.
11. Federal Specifications (FS):
    a. SS-S-00210 - Sealing Compound, Preformed Plastic, For Expansion Joints and Pipe Joints.

1.03 DELIVERY, STORAGE AND HANDLING:

A. Handle in a manner to ensure installation in sound and undamaged condition.
    1. Do not drop or bump.
    2. Use slings, lifting lugs, hooks, and other devices designed to protect pipe, joint elements, linings, and coatings.
B. Ship, move, and store with provisions to prevent movement or shock contact with adjacent units.
C. Handle with equipment capable of work with adequate factor of safety against overturning or other unsafe procedures.
D. If any defective pipe is discovered after it has been installed, it shall be removed and replaced with a sound pipe by the Supplier, at the Supplier's own expense. All pipe and fittings shall be thoroughly cleaned before installation and shall be kept clean until they are put into serive.
E. Provide factory-applied plastic end-caps on each length of pipe and tube. Maintain end-caps in place through shipping, storage, and handling to prevent pipe-end damage and eliminate dirt and moisture from inside of pipe and tube.
F. Where possible, store pipe, fittings, and equipment inside and protected from weather. Where necessary to store outside, elevate well above grade and enclose with durable waterproof wrapping. Protect material not suitable for outdoor storage to prevent damage during periods of inclement weather, including subfreezing temperature, precipitation, and high winds. Store materials susceptible to deterioration by direct sunlight under cover and avoid damage due to high temperatures. Do not store materials directly on the ground.
G. If special precautions are required, prominently and legibly stencil instructions for such precautions on outside of equipment or its crating.

H. Protect all material from dirt and dust, or other contaminants.
I. Handle equipment in such a manner as to ensure delivery to final location in sound, undamaged condition. Make satisfactory repairs to damaged material(s) at no cost to Owner.
J. Carry and do not drag materials.
K. Inspect materials delivered to site for damage; unload and store with minimum handling.

PART 2 - PRODUCTS Specified in respective Sections, this Division.

PART 3 - EXECUTION

3.01 INSTALLATION - GENERAL:

A. Installations shall conform to all requirements listed in City of Thornton Standards and Specifications or as listed in these specifications, whichever is more stringent.
B. Use equipment, methods, and materials ensuring installation to lines and grades indicated.
    1. Maintain within tolerances specified or acceptable laying schedule.
        a. Alignment: +/- 1 inch per 100 feet in open cut or tunnel.
        b. Grade: +/- 1 inch per 100 feet.
    2. Do not lay on blocks unless pipe is to receive total concrete encasement.
    3. Accomplish horizontal and vertical curve alignments with bends, bevels, and joint deflections.
        a. Limit joint deflection with ductile-iron pipe to conform to AWWA C600 and with PVC pipe to conform to AWWA C605.
        b. Limit joint deflection in DIP pipe to:
            (1) 5% with mechanical joint or 75% of the manufacturer's allowable, whichever is more stringent.
            (2) 3% with bell and spigot-rubber gasket joint 75% of the manufacturer's allowable, whichever is more stringent.
        c. Limit joint deflection in PVC pipe to:
            (1) 3% with mechanical joint or 75% of the manufacturer's allowable, whichever is more stringent.
            (2) 0.5% with bell and spigot-rubber gasket joint or 75% of the manufacturer's allowable, whichever is more stringent.
        d. Use short specials preceding curves as required.
    4. Obtain acceptance of method proposed for transfer of line and grade from control to the Work.
C. Install pipe of size, materials, strength class, and joint type with embedment indicated for plan location.
D. Insofar as possible, commence laying at downstream end of line and install pipe with bell ends in direction of laying. Obtain Engineer approval for deviations therefrom.
E. Clean interior of all pipe, fittings, and joints prior to installation. Exclude entrance of foreign matter during installation and at discontinuance of installation.
    1. Close open ends of pipe with snug-fitting closures.
    2. Do not let water fill trench. Include provisions to prevent flotation should water control measures prove inadequate.
    3. Remove water, sand, mud, and other undesirable materials from trench before removal of end cap.
F. Brace or anchor as required to prevent displacement after establishing final position.
G. Perform only when weather and trench conditions are suitable. Do not lay in water.
H. Observe extra precaution when hazardous atmospheres might be encountered.

I. All field joints shall be inspected prior to backfilling.

3.02 EXCAVATION, BEDDING AND BACKFILL:

A. Comply with the requirements of the following sections for excavation, bedding, backfill, and compaction:
   1. Section 31 20 00 – Site Preparation and Earthwork
   2. Section 31 23 13 – Subgrade Preparation
   3. Section 31 23 33 – Trenching and Backfilling for Utilities
   4. Section 32 11 23 – Crushed Rock Base Course

B. Comply with the requirements of the following sections for trench maintenance:
   1. Section 31 23 33 – Trenching and Backfilling for Utilities

3.03 JOINTING:

A. General Requirements:
   1. Locate joint to provide for differential movement at changes in type of pipe embedment, impervious trench checks, and structures.
      a. Not more than 8 inches from structure wall, or
      b. Support pipe from wall to first joint with concrete cradle structurally continuous with base slab or footing.
   2. Perform conforming to manufacturer's recommendations.
   3. Clean and lubricate all joint and gasket surfaces with lubricant recommended.
   4. Use methods and equipment capable of fully seating or making up joints without damage.
   5. Check joint opening and deflection for specification limits.

B. Special Provisions for Jointing Ductile-Iron Pipe:
   1. Conform to AWWA C600.
      a. Paint bell, spigot, or other suspected portions with turpentine and dust with cement to check for cracks invisible to the eye.
      b. Remove turpentine and cement by washing when test is satisfactorily completed.

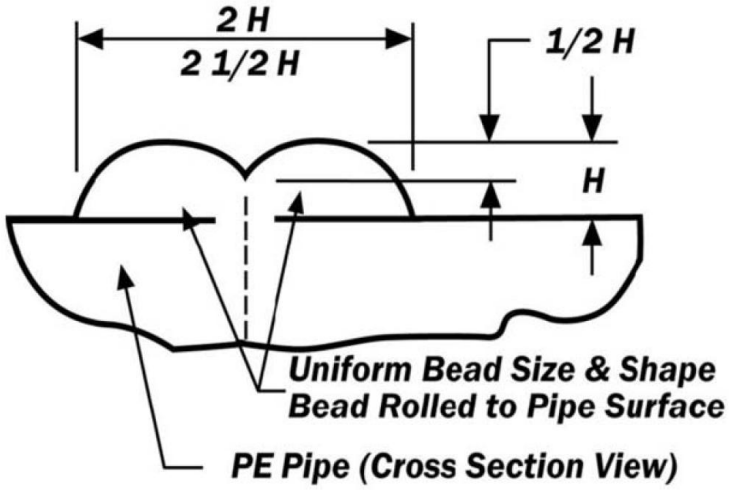
C. Special Provisions for Jointing Steel Pressure Pipe:
   1. Conform to AWWA M11.
   2. Check for holidays in coating and make repairs as required.
   3. Weld pipe and fittings to conform to AWWA C206.
   4. Grout inside joints of welded pipe and fittings mortar lined conforming to AWWA C205.
   5. Apply epoxy coating to inside of welded joints in pipe 24 inches and larger.
   6. Repair polyurethane coatings where held back or damaged during welding. Install per AWWA C222.

D. Special Provisions for Jointing PVC Pipe:
   1. Pressure pipe installation shall conform to AWWA C605 and AWWA M23.
   2. Excavate bell holes at each joint or coupling to provide full length barrel support of the pipe and to prevent point loading at the bells or couplings.
   3. Connect pipe to new or existing rigid structures with solid sleeve couplings.

E. Special Provisions for Jointing HDPE Pipe:
   1. Fused pipe shall be handled in a safe and non-destructive manner before, during, and after the fusion process and in accordance with this specification and pipe manufacturer’s guidelines.
   2. Pipe welds shall not be cooled using air cooled or air assisted equipment.
      a. Fastfusion® is strictly prohibited.

b. Fused pipe shall be allowed to cool using only ambient air temperatures.

3. Each fusion joint shall be recorded and logged by an electronic monitoring device (data logger) connected to the fusion machine.
4. Only appropriately sized and outfitted butt fusion machines that have been approved by the pipe manufacturer shall be used for the fusion process. Fusion machines must incorporate the following elements:
   a. Heat Plate – Heat plates shall be in good condition with no deep gouges or scratches. Plates shall be clean and free of any debris or contamination. Heater controls shall function properly; cord and plug shall be in good condition. The appropriately sized heat plate shall be capable of maintaining a uniform and consistent heat profile and temperature for the size of pipe being fused, per the pipe supplier's guidelines. The heat plate shall be capable of maintaining a surface temperature between 400 to 450 degrees F.
   b. Power – Must be self-generated or generator supplied for electrical requirements.
   c. Clamping – Shall be able to clamp the pipe axially to allow for subsequent operations to take place.
   d. Carriage – Carriage shall travel smoothly with no binding at less than 50 psi. Jaws shall be in good condition with proper inserts for the pipe size being fused. Insert pins shall be installed with no interference to carriage travel.
   e. Facer – the unit shall have a facer to establish clean, parallel mating surfaces, perpendicular to the centerline of each pipe. Facing blades specifically designed for cutting fused HDPE pipe shall be used.
   f. General Machine – Overview of machine body shall yield no obvious defects, missing parts, leaks of hydraulic system, or potential safety issues during fusion.
   g. Data Logging Device – An HDPE pipe supplier and Contractor approved datalogging device with the current version of the pipe manufacturer's recommended and compatible software shall be used. Datalogging device operations and maintenance manual shall be with the unit at all times. If fusing for extended periods of time, an independent 110V power source shall be available to extend battery life.
5. Other equipment specifically required for the fusion process shall include the following:
   a. Pipe rollers shall be used for support of pipe to either side of the machine
   b. Pipe cleaning solvent shall be accessible and used by the fusion crews at every joint. No oil or grease residue shall be present at the time of fusing.
   c. A weather protection canopy that allows full machine motion of the heat plate, fusion assembly and carriage shall be provided for fusion in inclement, extreme temperatures, and /or windy weather, per the pipe manufacturer's recommendations.
   d. Pipe rollers do need to be used for transporting the pipe unless there is risk of excessive/serious damage to the pipe.
   e. An infrared (IR) pyrometer for checking pipe and heat plate temperatures.
   f. Fusion machine operations and maintenance manual shall be kept with the fusion machine at all times.
6. On both sides of the joint, a double bead should be rolled over to the surface, and be uniformly rounded and consistent in size all around the joint. The double bead width should be 2 to 2-1/2 times its height above the surface, and the v-groove depth between the beads should not be more than half the bead height. Figure below illustrates the requirements.



7. Un-acceptable joints shall be completely removed and replaced.
   a. Un-acceptable joints include any of the following:
      (1) Visually un-acceptable joints as determined by Contractor and/or pipe manufacturer.
      (2) Joints determined to be out of manufacturer's specifications as measured in the field or collected by the fusion data logger.
      (3) Joints not recorded by the data logger.
      (4) Joints not visually inspected by the Contractor.

3.04 CUTTING:

A. Cut in neat manner without damage to pipe.
B. Observe Specifications regarding joint locations.
C. Cut cast-iron, ductile-iron, and steel pipe with carborundum saw or other acceptable method per manufacturer's instructions.
   1. Smooth cut by power grinding to remove burrs and sharp edges.
   2. Repair lining as required and approved.

3.05 CLOSURE PIECES:

A. Connect two segments of pipeline or a pipeline segment and existing structure with short sections of pipe fabricated for the purpose.
B. Observe Specifications regarding location of joints, type of joints, and pipe materials and strength classifications.
C. Field-fabricated closures, where required, shall be concrete encased between adjacent flexible joints.
D. May be accomplished with sleeve coupling:
   1. Of length such that gaskets are not less than 3 inches from pipe ends.

3.06 TEMPORARY PLUGS:

A. Plugs:
   1. Test plugs as manufactured by pipe supplier.
   2. Fabricated by Contractor of substantial construction.
   3. Watertight against heads up to 20 feet of water.
   4. Secured in place in a manner to facilitate removal when required to connect pipe.

3.07 COATING AND LINING REPAIR FOR STEEL OR DUCTILE IRON PIPE:

A. Repair coated steel or ductile iron pipe as indicated:
   1. At the coating plant (polyurethane).
      a. Conform to AWWA C2222.
      b. Test repaired area with a holiday tester. All holidays shall be repaired.
      c. Interior or pipe shall be electrically inspected for continuity at 2100 volts prior to exterior coating. If the number of holidays exceeds one per 3 linear feet of pipe 20 inches O.D. or smaller, or one per 2 linear feet of pipe over 20 inches O.D., the pipe shall be reprocessed. If not reprocessed, all defects disclosed by the holiday detector shall be repaired in shop according to Subsection 3.4 – Coating Repair of the ANSI/AWWA 213 specifications.
      d. Exterior of pipe shall be electrically inspected for continuity at 1965 volts. If the number of holidays exceeds one per 3 linear feet of pipe length for pipe smaller than 14 inches O.D., or one per 25 square feet of surface area for pipe 14 inches in O.D. and larger, the pipe shall be reprocessed. If not reprocessed, all defects disclosed by the holiday detector shall be repaired in shop according to Subsection 3.4 – Coating Repair of the ANSI/AWWA 213 specifications.
      e. In addition to the above requirements, check for coating defects on the weld seam centerlines. There shall be no porous blisters, craters, or pimples lying along the peak of the weld crown.
   2. In the field (liquid epoxy).
      a. Conform to AWWA C222.
      b. Test repaired area with a holiday tester. All holidays shall be repaired.
      c. Holidays, scratches and damages areas incurred while polyurethane field coatings shall be patched per the coating manufacturer's recommendations. Lightly abrade or sandblast the lining or coating on the sides of the damaged area before applying the coating. Patched areas shall overlap the parent or base coating a minimum of at least one inch in all directions. If a damaged area exceeds 20 square inches, the entire lining and coating shall be removed and the entire piece of pipe shall be recoated and retested.
      d. All exterior surface coatings shall be inspected electrically, following the same requirements for factory inspection procedure and voltage indicated above.

3.08 POLYETHYLENE ENCASEMENT:

A. Installation:
   1. Perform to conform to AWWA C105.
   2. Use adhesive tape to fasten polyethylene film in place.
   3. Minimize exposure of polyethylene film to sunlight.
   4. Wrap pipe, valves, fittings, and couplings per AWWA C105 installation standards.

3.09 CONNECTIONS TO EXISTING STRUCTURES:

A. Connect pipe to existing structures and pipelines where indicated.
B. Prepare structure by making an opening with at least 3 inches clearance all around fitting to be inserted.
C. Observe pertinent articles of Specifications pertaining to joint locations and closures.
D. Repair wall opening with modular seal (Link Seal) or use nonshrinking grout for non-circular holes.

3.10 CONNECTION TO EXISTING SYSTEM:

A. At locations where connections to existing waterlines are to be installed, the Contractor shall locate the existing lines both vertically and horizontally and verify their exact size and material in advance of the time scheduled for making the connections.
B. Prior to connecting to existing water mains, the Contractor shall measure the existing pipe for 'roundness'. If the pipe is determined to be 'out of round', Contractor to coordinate construction with Engineer before connecting.
C. Prior to connecting to existing water mains, the Contractor shall have all personnel, materials, and equipment ready to connect the fitting to the existing main, so as to keep the shutoff time to a minimum. As soon as possible after making the connections, the Contractor shall flush the connection so as to prevent contamination of the existing facilities. The Contractor shall take every precaution necessary to prevent dirt or debris from entering the main.
D. Connections to the existing water system shall be completed in a neat and workmanlike manner. The Resident Field Representative shall be notified at least forty-eight (48) hours in advance and be present at all times during the Construction of the connection. The connection is subject to approval by the Owner or Resident Inspector. Under NO circumstances shall a non-disinfected main, which cannot be isolated, be connected to an existing disinfected main.
E. The City does not guarantee the water tightness of its valves on existing facilities. If existing valves leak, the Contractor must use methods at his own disposal, to dewater the trench and complete any required testing or disinfection of the waterline.
F. All connections shall be valved to separate new construction from the existing system. Valves shall be kept closed until acceptance of the new system

3.11 CONCRETE THRUST BLOCKS:

A. Concrete thrust blocks are not to be used unless otherwise directed by Engineer or Owner.
B. Piping and fittings, 12-inches in diameter or less, with push-on or mechanical joints, or similar joints subject to internal pressure shall be blocked, anchored, or harnessed to preclude separation of joints. All push-on and mechanical joint bends deflecting 11-1/4 degrees or more shall be provided with suitable blocking, anchors, joint harness, or other acceptable means for preventing movement of the pipe caused by internal pressure.
C. Concrete blocking shall extend from the fitting to solid undisturbed earth and shall be installed so that all joints and bolts are accessible for repair.
D. The dimensions of concrete blocking shall be as indicated on Construction Detail Drawings may be used only if specified by the design professional on the approved for construction drawings. If support against undisturbed earth cannot be obtained, restrain joints. Restrained length shall be approved by the Engineer.
E. A maximum of eight (8) inches of backfill material may be placed over concrete arch encasement or concrete blocking after the initial set, to aid in curing. No additional backfill shall be placed over arch encasement or blocking until the concrete has been in place for at least one (1) day.
F. Reaction blocking, anchorages, or other supports for fittings installed in fills or other unstable ground, above grade, or exposed within structures, shall be provided as required by the Construction Detail Drawings and as directed by the Engineer.
G. All clamps, rods, bolts, and other metal accessories used in reaction anchorages, or joint harness subject to submergence or contact with earth or other fill material and not encased in concrete shall be protected from corrosion by two coats of approved coal tar applied in the field to clean, dry metal surfaces. The first coat shall be dry and hard before the second coat is applied. Metal surfaces exposed above grade or within structures shall be painted with one prime coat and two finish coats of a paint acceptable to the Engineer.

3.12 MARKING TAPE:

A. See SECTION 33 30 00.

3.13 FIELD TESTING:

A. Testing shall be performed on all pipelines per Table 1 in SECTION 33 11 50.
   1. Adhere to the latest version of the City of Thornton's Standards and Specifications and as modified herein.
   2. Acceptance Tests for Gravity Pipelines:
      a. Perform Low Pressure Leakage Test.
      b. Perform CCTV Video Test.

B. Low Pressure Leakage Test for Gravity Lines:
   1. See Section 304.4 of the City of Thornton's Standards and Specifications included as an attachment to this specification section.

C. CCTV Video Test for Gravity Lines:
   1. See Section 304.4 of the City of Thornton's Standards and Specifications included as an attachment to this specification section.

END OF SECTION 33 31 50

SECTION 33 39 00 - UTILITY STRUCTURES

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes the following structures and related appurtenances:
   1. Manholes - Stormwater, Electrical, Communication, etc
   2. Concrete anchor and thrust blocks.

B. Related Work Specified Elsewhere:
   1. Concrete: DIVISION 3.
   2. Masonry Mortar: DIVISION 3.

C. Applicable Standards:
   1. Grout around pipes with nonmetallic nonshrink grout.
   2. American Society for Testing and Materials (ASTM):
      a. A48 - Gray Iron Castings.
      b. C76 - Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
      c. C270 - Mortar for Unit Masonry.
      d. C443 - Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.
      e. C478 - Precast Reinforced Concrete Manhole Sections.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Concrete: Reinforced, conform to ASTM C478.

B. Mortar:
   1. Conform to ASTM C270 Type M.
   2. Type II portland cement.
   3. Proportion 1 part portland cement to not less than 2-1/4 nor more than 3 parts loose damp sand.

C. Castings:
   1. Manhole Steps:
      a. Steel reinforced polypropylene plastic or rubber, M.A. Industries Model PS2-PF, American Step Company Model ML, or equal as approved by Engineer.
   2. Manhole Frames and Covers:
      a. ASTM A48, Class 30B, pattern as specified for each structure under PART 3, this Section.
      b. Interchangeable within same pattern.
   3. Conform to Drawings in all essentials of design. Weight shall be within 10% of that listed for pattern.
   4. Machine-bearing surfaces to provide even seating.
   5. Coat with coal-tar pitch varnish.

PART 3 - EXECUTION

3.01 MANHOLES:

A. HS20 Loading

B. Design:

1. Construct (to conform to one of the acceptable alternatives described) as follows:
    a. Precast manhole with cast-in-place concrete base or precast concrete base:
        (1) Precast manhole shall conform to ASTM C478, except riser shall conform to ASTM C76, Class II pipe with rubber O-ring or ASTM C443 two-fin serrated flat gasket to concrete joint.
    b. Cast-in-place reinforced concrete manhole.
2. Conform to City of Thornton standard details.
3. Provide Submittal for precast and cast-in-place reinforced concrete manholes prior to installation.
    a. Submittal shall include Professional Structural Engineer seal calculations and shop drawings for the manhole design. Sealed drawings at a minimum shall include reinforcing details and material properties. Sealed calculations at a minimum shall include structure loading analysis, buoyancy analysis, uplift and lateral pressure analysis, material properties, and loading assumptions. Buoyancy calculations should have a factor of safety of 1.5 with water assumed to be at grade.
4. Caulk and repair any leaks or remove entire Work and rebuild to obtain watertight construction.

C. Manhole Frames and Cover:

1. Pattern as indicated on the Drawings.
2. Set frame level to proper grade on full bed of mortar.

D. Connections:

1. Grout around pipes with nonmetallic nonshrink grout.
2. Install all PVC piping using a flexible-rubber, entrance- hole gasket joint of pattern approved by the Contractor.
3. Make provisions for future connections where indicated.
4. Place pipe stub in manhole wall with bell or coupling outside manhole wall to provide flexible joint as indicated.
5. Include plug or stopper capable of withstanding 3 m (10 feet) 30 kPa (4.3 psi) of internal or external pressure without leakage for future connections.

E. Invert Channels:

1. Form invert channel with 27.6 MPa (4,000 psi) Type II portland cement concrete.
2. Make changes in direction of flow with smooth curves of as large a radius as size of manhole permits.
3. Make changes in size and grade smoothly and uniformly.
4. Slope floor of manhole adjacent to channels as indicated.
5. Finish channel bottom smoothly without roughness, irregularity, or pockets.

F. Waterproofing:

1. Apply coal-tar coating to exterior walls on all manholes from base to finish grade:
    a. Ertech 2100, or approved equal.
2. Apply first coat at 4 gallons per 100 square feet, allow to dry 24 hours, then apply second coat at 4 gallons per 100 square feet for 1/8” total wet film thickness. Confirm installation details with manufacturer recommendations.

3.02 CONCRETE ANCHOR AND THRUST BLOCKS:

A. Install at tees, elbows, bends, and dead ends where indicated.
B. Place against undisturbed earth or rock.
C. Of design indicated or specified:
    1. Bearing surface areas based on soil cohesive value (test) 12,250 kg/m^2 (2500 lbs/square foot).
    2. Apply two coats of coal-tar coating to minimum 0.5 mm (20-mil) dry-film thickness on anchor bars, straps, and hardware.

END OF SECTION 33 39 00

DIVISION 40 - PROCESS INTEGRATION

SECTION 40 60 00 – PROCESS CONTROLS AND INSTRUMENTATION – GENERAL REQUIREMENTS

PART 1 - GENERAL

1.01 SUMMARY:

A. This Division includes control devices, control panels, computer hardware and system programming as specified in this Section.

1.02 RELATED REQUIREMENTS:

A. DIVISION 26: All applicable Sections.
B. DIVISION 40: All applicable Sections.

1.03 REFERENCE STANDARDS:

A. National Fire Protection Association (NFPA):
   1. NFPA 70 – National Electrical Code (NEC).
B. Other standards as specified in applicable Sections.

1.04 SUBMITTALS:

A. Submit as specified in DIVISION 01.
B. Manufacturer with prime responsibility shall assume responsibility for all Compliance Submittals.
C. As specified in each applicable Section, this Division.

1.05 QUALITY ASSURANCE:

A. General:
   1. The Contractor shall provide the services of a single System Integrator (SI), to provide the material, equipment, labor, and services specified in this SECTION. The SI shall be subcontracted and under the direct supervision of the Contractor.
B. Acceptable System Integrators (SI):
   1. The communication, instrument and control systems may use Equipment of different manufacturers, but the System Integrator Subcontractor shall assume prime responsibility for the complete instrumentation and control system.
   2. No Bidder shall be required to employ any Subcontractor, other person, or organization against whom Bidder has reasonable objection.
   3. The SI shall be one of the following companies and shall follow Thornton cyber-security protocol:
      a. Automation Services
      b. Veolia/Suez
      c. No approved equal.
C. System Integrator Qualifications:
   1. Adhere to City of Thornton's Cybersecurity policy. Coordinate with the Owner.
   2. The instrumentation, control and communications system shall be furnished by a System Integrator (SI) who shall assume responsibility for the satisfactory performance of the entire plant control system. Only those SI who can demonstrate that they possess the prerequisite capabilities and experience shall be considered. The System Integrator subcontractor must meet the following minimum criteria:
      a. The SI shall have been in business for a minimum of five (5) years performing SI work on water and wastewater treatment projects and have control systems technicians with 5 years minimum experience with installation, testing, calibrating and startup of industrial control and automation systems.

b. The SI shall have specific training and experience with the following:
   (1) Schneider Electric x80 platform and EcoStruxure Control Expert Version 16.2 programming software.
   (2) Schneider Electric, Modicon M580 series of Programmable Automation Controllers and associated Unity Pro programming software.
   (3) GE Digital iFIX HMI/SCADA.
   (4) GE Historian.

1.06 SEQUENCING AND SCHEDULING:

A. Coordinate the installation of Equipment and Materials specified in this DIVISION with construction schedule.

B. The SI shall provide additional start-up assistance of actuator control during the WTP high flow period.

PART 2 - PRODUCTS

2.01 GENERAL:

A. Process Control Panel Components:
   1. Provide control panel components to integrate PAC equipment as indicated. New control panel components shall be provided to match existing control panel components.

B. Work in Existing PLC Cabinets:
   1. CP-100:
      a. Platform: Schneider Electric Modicon M580 series.
   2. Modify software as specified below in this Section.
   3. Panel Ancillaries:
      a. Provide terminal blocks, din rail, supports, circuit breakers, wire, tags, fuses, and other panel ancillaries as required to install new input/output cards in existing process control panels.
      b. Provide ancillaries to match existing installation.

C. New PLC Cabinets:
   1. PAC-MCP:
      a. Provided by Vendor.
      b. To match existing system standards for hardware and software and to adhere to the City of Thornton's Cybersecurity policy

PART 3 - EXECUTION

3.01 EXAMINATION:

A. Verify site conditions are suitable for installation of equipment and systems specified in this DIVISION.

3.02 INSTALLATION:

A. System Integrator shall be responsible for all cabling terminations at vendor control panels, process control panels and devices supplied by the System Integrator.

B. Refer to SECTION 26 05 19 – Low Voltage Cable for additional cable termination requirements.

3.03 SOFTWARE AND PROGRAMMING:

A. Modify existing plant control software to incorporate monitoring and control of new Equipment. Install new OITs for PAC Silo vendor system and create new high-performance HMI and OIT screens to match the design of existing screens. Existing OIT will remain as is.

B. Work in Existing PLCs:

1. CP-100:

a. Software Platforms: EcoStruxure Control Expert Version 16.2.

C. Coordinate programming with Owner.

3.04 FIELD QUALITY CONTROL:

A. Manufacturer's field services:

1. As specified in each applicable SECTION, this DIVISION.

B. Field Testing:

1. General Requirements:

a. Conform to requirements as specified in DIVISION 01.

b. Conduct all tests in the presence of Engineer under the supervision of Equipment manufacturer's field engineer.

c. Notify Engineer two weeks prior to the commencement of all tests.

d. Include all tests recommended by the Equipment manufacturer unless specifically waived by Engineer.

e. Include all additional tests recommended by Engineer that he deems necessary because of field conditions, to determine that Equipment and Materials and systems meet requirements of Contract Documents.

f. Be responsible for all damage to Equipment and Materials due to improper test procedures or test apparatus handling.

2. Instrument Tests and Adjustments:

a. Calibrate and startup measuring and controlling instruments in accordance with manufacturers recommendations.

b. With each system variable transmitter disconnected from its normal source of input signal, apply an input with manometer, instrument potentiometer, or other device and adjust span and zero on all instruments transmitting, receiving, or retransmitting the resulting variable current, voltage, time duration or pneumatic signal and on all final control devices. Check instruments and final control devices at several points over the instrument measuring or control device span.

c. Apply manually adjustable time duration or current signals directly to receivers where required to adjust zero and span and to check operation of the instrument over the measuring span.

d. Accurately measure variable current, voltage, time duration and pneumatic signals as required to adjust all receivers, transmitters, transducers, and final control devices.

e. Check operation of controller with various set points and system variable inputs; adjust controller proportional band, reset, and rate to conform to instructions from manufacturer's representative and Engineer.

f. Check operation of each instrument with system in actual operation.

g. Readjust controller settings as required to obtain desired control of the associated system variables.

3. Test Reports:

a. Submit test reports as specified in DIVISION 01.

b. Maintain a written record of all tests showing date, personnel making tests, equipment or material tested, tests performed, and results.

3.05 TRAINING:

A. The SI shall provide formal training for operators, maintenance, and service personnel.

B. A training schedule and log shall be developed. The training schedule shall identify scheduled dates and times for all training sessions specified in this DIVISION. The training log shall identify dates for training and record training session attendees.

C. Training sessions shall be scheduled with the Owner a minimum of two weeks prior to occurrence and a training schedule shall be maintained and communicated to the Owner on a routine basis.

D. Contractor shall make digital video recordings of all on-Site training for training purposes. Any charges for this video recording shall be included.

E. Provide training as specified in each applicable SECTION, this DIVISION.

END OF SECTION 40 60 00

SECTION 40 61 96 – PROCESS CONTROL SOFTWARE PROGRAMMING AND REPORTS

PART 1 - GENERAL

1.01 SUMMARY:

A. This section includes process control system (PCS) programing requirements. This section includes but is not limited to the following:
   1. Programmable Logic Controller (PLC) Programing Software.
   2. Operator Interface Terminal (OIT) Programing Software.
   3. License requirements.
   4. Graphics requirements.

B. This Section includes general control descriptions and requirements for the PLC and control system software programming.

C. Make the PCS work together as a whole complete system. Including PLC logic, Human Machine Interface (HMI) graphics, OIT programming, motor controllers, networking and control system programming.

D. HMI/OIT graphics associated and supplied with the process equipment skids shall be coordinated for a common look and feel to that of the main plant controls but programed by the equipment supplier.

E. The programing shall be performed based on the control system manufacturer enterprise software with common libraries programing blocks symbols and alarm interface.

1.02 RELATED REQUIREMENTS:

A. SECTION 01 33 00 – Submittals.
B. SECTION 01 40 00 – Contractor QA/QC.
C. SECTION 01 42 00 – Definitions and Standards.
D. SECTION 01 78 36 – Warranties.
E. SECTION 40 66 00 – Process Control Networks.
F. SECTION 40 67 00 – Process Control Panels and Hardware.
G. SECTION 40 68 00 – Process Control Software.
H. SECTION 40 70 00 – Instrumentation for Process Systems.

1.03 REFERENCE STANDARDS:

A. International Society of Automation (ISA).
   1. 101.01 – Human Machine Interfaces for Process Automation Systems.

1.04 SUBMITTALS:

A. In addition to the requirements of SECTION 01 33 00, submittals shall include the following:
   1. Product Data: Submit for each type of product specified and included the following as minimum:
      a. A complete listing of all proposed HMI/OIT graphics and the corresponding points and parameters displayed.
      b. Proposed standard HMI/OIT and PLC objects for the project (i.e. pump control, valve control, etc.). Inputs and outputs developed for each object shall be identified.
      c. Submit a minimum of two electronic sample graphic screens developed for similar projects.
   2. Shop drawings:
      a. A functional description of how the equipment should be controlled and operated. Include a list of parameters with setpoints to be monitored, controlled and alarmed.
      b. Power Failure and Restoration programing:

(1) Provide a complete description of the power failure and restoration mode programming.

c. Complete list of IP Addresses for all network connected devices.

d. Submit as delivered onsite (post Factory acceptance test) for the entire system including:
   (1) PLC Logic and database programing.
   (2) HMI Graphics.
   (3) OIT programing.
   (4) OIT graphics.

e. Submit as constructed (post Site Acceptance) for the entire system including:
   (1) PLC Logic and database programing.
   (2) HMI Graphics.
   (3) OIT programing.
   (4) OIT graphics.

3. Maintenance Material Submittals:
   a. Software:
      (1) Assemble and submit all software and program copies in native format.

1.05 QUALITY ASSURANCE:

A. As specified in SECTION 01 40 00.

1.06 WARRANTY:

A. The warranty shall comply with the requirements of SECTION 01 78 36.

PART 2 - PRODUCTS

2.01 GENERAL:

A. Programing as indicated on the P&IDs and as specified in the Contractor-furnished equipment procurement packages.

PART 3 - EXECUTION

3.01 GENERAL:

A. The intent of the control system specified and indicated is to provide complete control and monitoring capabilities for the WBWTP PAC facility and associated ancillary equipment.

B. The PLCs shall be programmed to communicate the required data to the associated I/O servers via the communication network as required by the control system manufacturer.

C. HMI graphics and programing logic shall be developed for control interface and monitoring of the systems described.

D. All set points and time delays are initial values and shall be adjustable by the System Administrator through the Engineering interface not through the HMI graphics.

E. Coordinate with Suppliers for communication of specified points between the network servers and the manufacturer supplied PLC’s.

F. HMI graphics shall be developed to display status and provide control interfaces for the manufacturer supplied equipment.

G. Coordination with System Suppliers:
   1. The graphics associated with the vendor supplied systems will be developed by the Suppliers.

2. Coordinate graphic layout, including screen titles, alarm symbols and locations, navigation buttons.
3. Coordinate standard equipment control logic for each type of equipment in order for the whole control system to share the same typical graphics, faceplates, symbols, and function blocks, including status and indication for:
    a. Manual and auto modes.
    b. Hand-Off-Auto Status.
    c. Manual start and stop commands.
    d. Auto starts and stop commands.
    e. Running, stopped and alarm states.
    f. Fail to start, fail to stop, permit to start and override stop states.
4. Coordinate standard valve control logic for each type of valve in order for the whole control system to share the same typical graphics, faceplates, symbols, and function blocks, including status and indication for:
    a. Manual and auto modes.
    b. Remote-Local Status.
    c. Manual open or close commands.
    d. Auto open and close commands.
    e. Opened, closed and alarm states.
    f. Fail to open, fail to close, permit to open/close and override open/close states.
5. Coordinate alarm management, priority, and alarm protocol. Including:
    a. This shall include standard alarm level
6. Coordinate to ensure required control and monitoring signals are communicated correctly across the PCS network.
7. Motor controllers and VFDs shall be connected to the PCS network for data collection. Controls are to be configured as hardwired. Refer to the Drawings for controls schematics.
8. As a minimum the System supplier and SI shall participate in two web conferences setup by the SI and attended by the Contractor to determine programming standards, verify proper application of the standards and coordinate communicated signals.
    a. The first web conference shall occur one month after notice to proceed and before the system suppliers have started programming efforts to layout the standard graphic layout requirements, equipment and valve control logic used in the PCS.
    b. A 30% Graphic package shall be submitted for Owner and Engineer review. Submit at least the following:
        (1) HMI/OIT Login Screen (password protected with read-only and control credentials. Coordinate passwords with Owner I&C supervisor)
        (2) Main Screen
        (3) Chemical Feed Pump Screen
        (4) Water Quality Station Screen
        (5) Alarm log screen
        (6) Set points screen
        (7) 1 Trending Screen
    c. The second web conference shall occur after initial screen development and logic development and shall serve as a review meeting to verify that proper standards have been followed and proper points are being communicated.
    d. Follow up conferences shall occur as required during development and after initial development is completed to ensure the agreed to standards are being followed,

discuss progress, verify communicated points and address any outstanding communication questions.

3.02 HMI STANDARDS AND GRAPHIC DEVELOPMENT:

A. General:
1. HMI graphics shall be developed for control interface and monitoring of systems and facilities and related equipment.
2. Where possible, standard objects shall be developed and utilized throughout the project. Objects shall be developed for flexibility with nested blocks within blocks where necessary and with the worst-case scenario in mind to allow blocks to be adaptable throughout the project. Proposed blocks shall be submitted as specified.
3. All graphics shall be developed using graphics and icons from the manufacturer's enterprise software library when possible. The graphic displays shall be developed using design elements and concepts intended to enhance the operator's "Situational Awareness". The development, design, and implementation of the system displays shall comply with ISA 101.01 – Human Machine Interfaces for Process Automation Systems.
4. HMI graphics shall be developed based upon a 1920x1080 (16:9) ratio and shall allow for multi monitor display.
5. All HMI graphics shall be developed with input from the Owner and Contractor and all graphics shall be approved by the Owner prior to startup of the system.
   a. The SI shall schedule necessary meetings with the Owner and Contractor to properly coordinate graphic development, layout, and other required Work to ensure the developed graphics and systems best meet the needs and desires of the Owner for operating the facility.
6. All analog values shall be trended and recorded in the historical database.
7. Low, low-low, high and high-high and loss of signal alarm points shall be programmed and available to set for all analog points. The operators shall be able to set values for or disable the alarm points from the HMI graphics. If alarm range settings are not provided the alarm settings shall be adjustable over the entire range of the associated the analog value.
8. A minimum of one decimal point of accuracy shall be provided for all analog points displayed on the HMI. Additional decimal places shall be provided where applicable.
9. All automatic control such as start/stop, speed control, flow control, and similar shall be programmed into the nearest local PLC processor. All manual controls such as start/stop, open/close, speed control, etc. shall be incorporated into the PLC programming and graphics as described this section. All control shall take place in the PLC with the applicable computer servers, workstations, and HMI graphics maintained for operator interface only.
10. Provide run time totalization for all equipment in the nearest local PLC processor and display the current value on the relevant graphic(s).

B. Security Access Levels:
1. Provide at a minimum four levels of access to the control system:
   a. Guest Level: allows viewing of plant status but no control.
   b. Operator:
      (1) Password Protected.
      (2) In general, allows the operator control the process equipment within the designed and programmed ranges.
      (3) Allows for selection of operational modes.

(4) Allows for starting and stopping of equipment
(5) Adjustment of manual and automatic setpoints.
(6) Allows printing of graphics.

c. Supervisor:
(1) Password Protected.
(2) In general, allows programing updates to the graphics, and tunable logic settings to increase or decreases ranges, timers and default setpoints.
(3) All functions of Operator Level.
(4) Allows changes to be made to alarm setpoints, time delays and the ability to inhibit alarms.
(5) Allows printing of control system programing.

d. Administrator:
(1) Password Protected.
(2) In general allows full access for reprograming of the entire control system, including graphics, logics, I/O & alarm databases, historian management.
(3) All functions of Supervisor Level.
(4) Allows for adjustments to code and programing.

e. Coordinate passwords with Owner's I&C Supervisor.

C. Hierarchy:

1. HMI graphics shall be organized in a hierarchical manner and designed to allow efficient movement between each of the levels within the hierarchy. Each graphic shall also implement relational links between nodes of a specific process when applicable, e.g. through process piping or flow interconnections. The relational links should allow the user to navigate the various graphics by following the process flow stream:

Level	Type	Description
1	Facility Overview	Provides an overview for the entire facility geographically and/or in process flow diagram format. Identifies major equipment, valves, abnormal status, and key process parameters for the facility.
	Alarm Summary	Identifies all top priority alarms, alarm history, and acknowledged status. Allows an administrator to inhibit or activate alarms
	Historical Trends	Displays of embedded or full-graphic trends.
2	Process Displays	Designed to be the primary operating display for normal operation and monitoring of a specific process. Includes equipment, associated status, alarm, and instrumentation.
3	System or Subsystem Detail Displays	Displays interfaces necessary for equipment control, indicators, switching, and setpoint adjustment (when applicable). Includes all associated status and alarm conditions for the equipment providing sufficient information for process diagnostics.
4	Diagnostic and Informational Displays	Provides operational procedures and/or help information such as interlocks and permissive information. Not intended for process or system control. Generally displayed in the form of faceplates or popups.

D. Presentation and Content:
   1. Coordinate the graphic layout and symbols philosophy of each graphic and review with the Suppliers, Owner and Contractor during the preliminary development phase.
   2. The presentation for each graphic shall be designed to maximize the user's ability to navigate, enter data, and monitor the associated information.
   3. All graphics shall include:
      a. A global navigation menu at the bottom of the graphic.
      b. Alarm indication in the upper right corner of the graphic with button or link to an alarm list.
      c. Graphic Title at the top of the graphic.
      d. Pull down menus, pop-up windows, buttons, following a standard template for the project.
   4. The graphics shall generally follow the process flow from left to right. If specific types of graphics benefit from a geographical layout (e.g. overview), exceptions shall be reviewed and approved by the Owner and Contractor.
   5. The graphics shall use standard library symbols to represent all major pieces of equipment at the facility including tanks, pumps, fans, piping, valves, gates and instrumentation as indicated on the P&IDs. The symbols shall be representative of the types of equipment and tanks, e.g. mixers, centrifugal pumps, vertical turbine pumps, progressive cavity, open basin vs covered etc.
   6. Equipment not controlled through the control system, such as manual gates and valves, should be minimally shown and indicated as such.
   7. Equipment shall indicate the equipment tag below each piece of equipment on the graphics, and the equipment description on each or the equipment's pop-up faceplate.
   8. Vessels and similar tankage should be depicted in similar shape to their actual physical shape. Shapes should typically be two-dimensional, keeping details to a minimum. Size should reflect importance and/or be representative of the vessel physical size in relationship to other vessels shown within the display. Dynamic elements should be located within the vessel shapes such as embedded trends when process variables such as level, flow, or similar are being monitored for the associated vessel or pipe.
   9. Protocol shall be established which animates alarms prior to being acknowledged and maintains alarm display until the alarm condition is removed or the alarm is inhibited. Alarms, alarm acknowledgement, and inhibits shall be recorded to an event log.
      a. An audit graphic shall be developed to allow a Supervisor or Administrator to view inhibited alarms and to inhibit nuisance alarms.

E. Display Elements and Color Conventions:
   1. Colors shall be used to enhance the user's ability to recognize the importance of key information such as alarms and other abnormal conditions.
   2. Color selection shall be used to distinguish the type of information being displayed with higher priority information being emphasized using the most noticeable colors.
   3. Color shall be used conservatively and consistently throughout the displays.
   4. Colors used for alarms shall not be used for any other purpose to ensure their meaning is strengthened.
   5. Recommended colors have been identified in the table below for commonality between equipment manufacturer developers and SI. Red, Green and Blue (RGB) levels are provided in addition to the equivalent Hue, Saturation, and Luminance (HSL) values. These colors shall be used as a guide for developing all displays. Note that some colors

may be listed but not utilized for the project. Additional colors may be used when in conformance with the design philosophy specified herein and approved by the Owner and Contractor.

Color	Red	Green	Blue	Hue (°)	Sat (%)	Lum (%)
Black	0	0	0	0	0	0
White	255	255	255	0	0	100
Light Gray	204	204	204	0	0	80
Gray	140	140	140	0	0	55
Dark Gray	76	76	76	0	0	30
Cyan	163	245	245	180	80	80
Dark Cyan	23	206	206	180	80	45
Green	132	191	64	88	50	50
Light Green	181	217	140	88	50	70
Dark Green	79	115	38	88	50	30
Brown	115	84	38	36	50	30
Light Brown	204	163	102	36	50	60
Magenta	255	0	255	300	100	50
Light Magenta	255	179	255	300	100	85
Dark Magenta	128	0	128	300	100	25
Red	223	32	32	360	75	50
Light Red	242	166	166	360	75	80
Yellow	242	242	13	60	90	50
Light Yellow	251	251	182	60	90	85
Orange	242	128	13	30	90	50
Light Orange	247	179	110	30	90	70

6. Static Display Elements:
   a. Static display elements and process flow streams shall conform to the table below.

Static Elements	Color
Graphic Display Background	Light Gray
Static Text: Display Titles Equipment Identifiers Equipment Symbol Outlines	Black
Static Equipment Symbols: Isolation Valves Flow Meters Similar Devices Process Symbol Outlines	Black

Static Elements	Color
Static Process Symbols: Basins Filters Vessels	Gray
Primary/Major Process Flow Streams:	Dark Gray
Secondary/Minor Process Flow Streams:	Dark Gray
Chemical Feed Systems:	Gray
Compressed Air, Instrument Air	Gray

7. Lines and Arrows:
   a. Lines and arrows used for the primary process flow shall be easily distinguished from secondary flows and instrumentation.
   b. Process lines shall be shown as solid with instrument lines shown as dashed.
   c. Line crossings shall give precedent to the primary process flow with the secondary lines being split.
   d. Each process flow line shall be labeled at the entrance and exit of each display and identify flow direction.
   e. When the flow line continues to another display, the entrance and exit of each flow line shall include a link to the next display associated with the flow.
   f. Arrows used for links shall be distinguished in appearance from non-linked arrows.
   g. Line weights and patterns shall be as follows:
      (1) Primary Process Flow: 4 point line weight with solid pattern.
      (2) Secondary Process Flow: 3 point line weight with solid pattern.
      (3) Chemical Feed and other Minor Flows: 2 point line weight with solid pattern.
      (4) Instrumentation Lines: 1 point line weight with dashed pattern.
8. Dynamic Display Elements:
   a. Dynamic symbol and text elements, both discrete and analog, shall conform to the requirement as specified below.
   b. Color for dynamic elements shall be used for process variables, warning, and alarm conditions. Colors shall be used to represent the priority of the associated condition, e.g. low, high, critical, etc.
   c. The dynamic elements used shall place emphasis and promote situational awareness for the operator.
   d. Equipment modes shall indicate whether the equipment is in local, off, or remote.
   e. Equipment status shall indicate running and stopped, open and closed, etc.
   f. The quality of the signal shall be represented to indicate out-of-service, inhibited alarm, bad data or communication failure.
   g. Symbols shall be emphasized using a separate colorized flashing box around the object to indicate unacknowledged alarms, signals out of range, and those not having proper communication. If the specific project implementation requires more than two priorities (warning and alarm), the flashing box shall also include a priority identification symbol attached to the box.
   h. Refer to the following table for each dynamic element's associated color and usage.

Element	Color	Usage
Pumps, Fans, Blowers, and other two-state devices	Dark Gray	Running, On or Open
	White	Stopped, Off, or Closed
Throttling Valves and other Modulating Devices.	Dark Gray	Fully Open
	White	Fully Closed
	Half Dark Gray/Half White	In Transition
Alarm Conditions	Yellow Flashing Box	Warning
	Red Flashing Box	Alarm, Unacknowledged
	Gray/Dark Gray Hatching	Out-of-Service
	Magenta Box	Comm. Error / (Old Data)

9. Control Function Interfaces:
   a. Control functions requiring operator interaction or input such as hand-off-auto selection, mode selection, setpoint input, and similar shall be presented in a control panel pane integrated into the associated display windows when possible. A pop-up window shall be used if space is limited on the equipment display. The appearance of the operator interfaces shall be consistent in either presentation.
   b. PID setpoint, process variable, output and other tuning parameters shall be made available through this control panel interface when applicable. If the security access level is not sufficient, the parameters shall be hidden or made unavailable for user interaction.
   c. Buttons and setpoint entry fields used for process control shall be designed with a raised appearance or perceived depth to allow immediate recognition of its function by the Operator.
   d. Setpoint entry fields shall be clearly labeled with the appropriate units displayed and also be raised in appearance.
   e. Navigational buttons should be distinct from buttons used for process control.
   f. Button colors and setpoint fields shall be as identified in the table below.

Element	Color	Usage
Button (Active/Enabled)	Dark Gray	Button Fill
	Dark Green	Button Text
	White / Gray	Border and Shading
Button (Inactive/Disabled)	White	Button Fill
	Dark Blue	Button Text
	Dark Gray / Gray	Border and Shading
Setpoint Input Field	White	Background Fill
	Dark Gray / Gray	Border and Shading
	Dark Green	Setpoint Text

10. Dynamic Text and Bar Graphs:
   a. Dynamic text shall be used to represent a discrete or analog signal on the operator HMI.

(1) Dynamic text elements shall be colorized to distinguish them from static text, in addition to flashing boxes used for identifying warning and alarm conditions.

b. Bar graphs may be utilized in addition to dynamic text elements to represent process variables.
   (1) Bar graphs may be used for process variables such as level, speed, and other analog instrumentation.
   (2) The bar graph shall be segmented to identify the variable setpoint, warning and alarm ranges in addition to the current value.
   (3) Bar graphs shall not change color or flash to represent a warning or alarm condition. Similar to other dynamic elements, a colored box around the associated bar shall be used for this purpose.

c. Color conventions for dynamic text and bar graph elements shall be as identified in the table below.

Element	Color	Usage
Bar Graphs and Other Bar Style Elements.	Dark Blue	Process Variable
	Cyan	Normal Range
	White	Warning Range
	Dark Gray	Alarm Range
	Dark Green	Setpoint
Dynamic Text	Dark Blue	Process Variable
	Dark Blue w/Flashing Yellow Box	Warning, Unacknowledged
	Dark Blue w/Yellow Box	Warning, Acknowledged
	Dark Blue w/Flashing Red Box	Alarm, Unacknowledged
	Dark Blue w/Red Box	Alarm, Unacknowledged
	Magenta w/Magenta Box	Communication Error/Old Data

11. Display Text:
   a. Both dynamic and static text elements shall be consistent for all displays.
   b. Arial 16-point bold font shall be used for headings and titles.
   c. Arial 12-point bold font shall be used for all other text.
   d. Text color shall be as previously defined.
   e. Labels and other static text element colors not previously defined shall utilize shades of dark gray and black to sufficiently contrast against the light gray background.
12. Alarm Text:
   a. In addition to the warning and alarm condition box animations defined in previous sections, alarms shall be displayed in text form in the alarm window. The alarm display text colors conventions shall be as defined in the table below.

Element	Text Color	Text Background Fill	Usage (Priority Level)
	Black	Red, Flashing	Alarm Unacknowledged (1)
	Black	Red	Alarm, Acknowledged (1)

Element	Text Color	Text Background Fill	Usage (Priority Level)
Alarm Display Window Text (Active)	Black	Light Red	Alarm, Return (1)
	Black	Yellow, Flashing	Warning, Unacknowledged (4)
	Black	Yellow	Warning, Acknowledged (4)
	Black	Light Yellow	Warning, Return (4)
	Black	Orange / Light Orange	Priority 2 (If required), Flashing
	Black	Magenta / Light Magenta	Priority 3 (If required), Flashing
Alarm Display Window Text (Suppressed)	Black	White	Alarm
Alarm Display Window Text (Inhibited)	Black	Gray	Alarm
Alarm Display Window Text (Shelved)	Black	Light Brown	Alarm

F. Screen Development: As a minimum the following screens shall be developed for the project:
   1. Detailed System Screens:
      a. A detailed process screen based on the P&IDs shall be developed for each process system.
      b. The detailed screens shall display all monitored parameters and allow for the adjustment of the control and alarm associated with the system.
      c. If a particular system requires additional screens to clearly identify and display all control and status points for the system equipment the Detailed Screen and Overview Screen shall include links to the additional subsystem screens.
      d. Links shall be established between related screens and for process piping continuations between screens.
      e. Detailed graphics shall be developed for each system. Some graphics may be combined as indicated on the P&IDs including, but not limited to, the following:
         (1) PAC silo system (By Supplier)
   2. Chemical Feed Parameter Screens: Parameter screens shall be programmed so that the operators can see an overview of the entire chemical storage and feed system and enter the data in only one location and the program can access the data as needed to include the following:
      a. PAC Silo Parameter Screens:
         (1) Data Input:
            (a) Chemical name
            (b) Bulk density of active chemical (lbs/gal)
            (c) Additional chemical system components to be shown on chemical feed system screen:
               1). Silo level (ft)
               2). Feed blower feed rate (lbs/hour)
               3). Feed blower discharge pressure (psi)
   3. Alarm and Event Management Screens:
      a. Shall display alarms and events.

b. Shall list the discrete alarm points and allow the operator to inhibit the alarm and select whether the alarm point causes the audible alarm to sound.
c. Shall allow the operator to set the parameters associated with the audible alarms.
d. Shall allow the operator to place the associated equipment alarms into "Out Of Service" mode to prevent out of service equipment from triggering alarms.
e. Color schemes and display properties shall be as defined this Section.

4. Event Notification:
   a. The following methods shall be used for notification of alarms:
      (1) Alarms shall be sent via WIN911 SMS to operators.
      (2) Alarm screens and alarm box animations for each process variable displayed.
      (3) Audible alarms via PC workstation speakers.
      (4) Remote alarms via radio network.
5. Maintenance Screens:
   a. Maintenance screens shall be developed for each system and associated equipment.
   b. The maintenance screens shall provide links to electronic O&M materials, As-Built drawings stored in PDF format, maintenance and calibration records in excel format.
   c. The PDF's shall be supplied as part of the manufacturers O&M material and final documentation. The systems integrator shall assemble all of the electronic documents in a common area on the control system server.
   d. Specific portions of the electronic documents to be accessed more frequently should be pulled from the full O&M documents and stored as separate PDF files for quicker access. The specific portions to be separately stored shall include, but not be limited to, the following items:
      (1) Wiring diagrams.
      (2) Pump Curves.
      (3) Manufacturer's recommended maintenance schedules.
      (4) Other items as requested by the Owner.
   e. As-Built drawing PDF's shall be supplied by the Subcontractor after the plant construction is completed. The SI shall utilize the "For Construction" drawing PDF's for the initial development. After the As-Built PDF's are supplied the SI shall replace the contract drawing PDF files with the final As-Built files.

3.03 REPORTS:

A. Reports shall be developed with input from the Owner for specific formatting and data presented.
B. Reports shall be designed in a professional manner with Titles, Headings, Dates, and other relevant information, which describe in detail the reported information.
C. Reports shall be developed utilizing the control system manufacturers enterprise reporting software platform.
D. As a minimum the following reports shall be developed for each plant:
   1. Operator initiated report listing all operator adjustable set points. The report shall include both control and alarm values with headings indicating associated equipment.
   2. Reporting information as required by Owner.
      a. Assume a minimum of 3 additional reports to be developed for each plant based upon input from Owner.

b. Report formatting and style shall be coordinated with the Owner and Contractor during development. Final report shall be submitted for review and approval by the Owner and Contractor.

E. Reports shall be generated automatically on the defined periodic basis and saved in Excel format to a common directory on the Administration Building Workstation. The operator shall be able to initiate a report to generate at any time by manually initiating the particular report. File naming convention shall be intuitive and define the report name, date, and applicable saved data.

3.04 NETWORK CONFIGURATION:

A. The plant control system Ethernet network shall be configured as specified in Section 40 66 00 – Network and Communications Equipment and as indicated on the contract drawings.

B. The SI shall be responsible for programming and verifying the IP Addresses, Subnet, and Default Gateways, when applicable, for all devices on the network.

C. The network IP addresses shall be defined based on the Ethernet Network TCP/IP Addresses indicated on the network architecture diagram. Addresses for devices not listed in the table shall be assigned by the SI within the specified ranges.

3.05 PROGRAMMABLE LOGIC CONTROLLER (PLC) PROGRAMMING:

A. The PLCs shall be programmed utilizing EcoStruxure Control Expert Version 16.2software.

B. The PLC program shall be thoroughly documented with comments explaining the code for each operation performed.

C. Where possible the PLCs shall be programmed utilizing object oriented programming (OOP) blocks and user defined data types (UDT) to maintain consistency throughout the PLC program. Programming blocks shall be developed with the worst case scenario in mind to allow blocks to be adaptable throughout the project. Proposed blocks shall be submitted as specified.

D. The PLC shall be programmed to perform the required logic for proper operation of the associated equipment.

E. The PLC shall monitor communications status through a heartbeat monitor to each PLC on the network and alarm if communication failures occur.

F. The PLC shall monitor power status of the building or structure power supply. Logic shall be implemented that shall clear run contacts or shut down equipment when power to the facility is lost and perform routine startup of equipment after power restoration. Operator adjustable time delays shall be established between the restarting of motor driven equipment.

G. Each alarm point shall have a programmed 2 second time delay to prevent “nuisance” or “false” alarms.

H. Momentary start contacts shall be programmed to close for 2 seconds and then open. Momentary stop contacts shall be programmed to open and stay open until shutdown of the motor is detected.

I. All required field programming and tuning of the control loops shall be included.

3.06 INTERFACE TO EXISTING SCADA SYSTEM:

A. A SCADA interface shall be provided to communicate with the existing control system at the water treatment plant.

B. HMI graphic shall be developed on the existing operator stations for monitoring water treatment plant.

C. All modifications and additions to the existing control system shall be coordinated with the Owner.
D. The following screens shall be developed on the Owner's existing system with the specific I/O points listed arranged within the graphical screens in a practical manner. The new screen color scheme and symbology shall match the existing screens.
   1. Overview Screen.
      a. General Layout.
      b. Process system graphics.
         (1) Run status.
         (2) Fail Alarm.
         (3) Temperature Alarm.
         (4) Discharge Pressure.
         (5) Alarm status's
         (6) Levels.
         (7) Flow rates.
      c. Electrical and Mechanical Equipment status.
      d. Communications:
         (1) Communications Failure Alarm.

3.07 PROCESS DESCRIPTIONS:

A. Refer to P&IDs or Supplier control narratives for each systems process programming requirements.
   1. PAC Silo System:
      a. The PAC silo system supplier shall control the PAC silo weight elements, dust filter, screw conveyors, and other equipment provided by the silo system supplier necessary for proper operation of the system. The PAC silo system supplier shall provide a vendor control panel and be responsible for the programming of their system to achieve this.
      b. The silo vendor system PLC shall be connected to the process control network via network and owner required hardwired controls.
      c. The SI shall coordinate with the vendor to incorporate the silo system into the treatment plant SCADA system.
   2. PAC Silo Weight Elements:
      a. Weight elements shall operate according to Section 46 36 15. Individual load cells shall connect to a summing card and transmitter for SCADA control.
      b. At all times, SCADA shall display the total (summed) weight of the silo in pounds (lbs) from WQ/WIT-143.
      c. The following alarms shall be programmed in SCADA:
         (1) High/Full: Weight exceeds 162,000 pounds.
         (2) Reorder: Weight below 80,000 pounds.
         (3) Low: Weight below 40,000 pounds.
   3. PAC Pretreatment Facility Basin:
      a. To batch PAC slurry inside the existing PAC Pretreatment Facility Basin, the silo must be dispensing PAC to the basin while water is simultaneously being fed to the basin. The basin mixer must operate to incorporate the PAC into the slurry, and the basin dust collector must be on to prevent dust accumulation. Slurry ratio must comply with 1 pound of PAC per 1 gallon of water.
      b. PAC Batching Sequence:

(1) To Start: Start PAC basin dust collector DC-118 and open valve V-153.
   (a) DC-118: prevents dust accumulation within basin during filling.
   (b) V-153: 4" motorized spray down valve, dampers dust as it enters the basin.
(2) The PAC silo dispensing sequence, outlined in Section 46 36 15, cannot begin unless a signal is received from DC-118 and V-153. Once signal received, allowed, PAC silo dispensing sequence begins.
(3) The PAC silo will deliver 8,300 lbs of PAC per hour for a duration of 4.8 hours (288 minutes) prior to issuing stop signal. To maintain 1 pound of PAC per 1 gallon of water ratio, throttle V-152 to maintain a feed rate of 138 gpm in FE/FT-151.
   (a) V-152: 4" motorized supply valve, fills basin with water for slurry
   (b) FE/FIT-151: supply water flowmeter
(4) After a duration of 3 minutes, start PAC basin mixer M-112.
(5) To Stop: After a duration of 4.8 hours (288 minutes), issue stop signal for DC-118, V-153, V-152, and M-112. PAC silo dispensing stop to follow Section 46 36 15.

4. Lagoon Effluent Monitoring:
   a. AE/AIT-191-TSS and AE/AIT-192-CL shall display output in SCADA at all times.
   b. AE/AIT-191-TSS shall alarm if reading exceeds 30 mg/L.
   c. AE/AIT-192-CL shall alarm if reading exceeds 1.0 mg/L.

3.08 FIELD QUALITY CONTROL:

A. Field Testing:
   1. As specified in Section 40 60 00 – Process Control and Instrumentation General Requirements and each applicable equipment Section.
   2. A testing plan shall be developed and submitted for approval prior to testing of the control system.
   3. Each mode of operation shall be tested along with fault conditions for proper system response.
   4. Prior to and during initial startup period Systems Integrator shall demonstrate all modes of operation and step through various operating and failure scenarios.
      a. Startup and operation mode testing shall be witnessed by the Contractor.
      b. Subcontractor shall notify the Contractor a minimum of 2 weeks prior to the specified startup testing.

B. Test Reports:
   1. Submit test reports as specified in Division 01.
   2. Maintain a written record of all tests showing date, personnel making tests, equipment or material tested, tests performed, and results.

3.09 TRAINING:

A. The SI shall provide formal training for operators, maintenance and service personnel.
B. The training session shall include classroom discussion on the theory of operation of the control system as well as maintenance and service methods for the system. Topics covered shall include functionality of the system, system navigation, data management and recommended backup procedures.
C. Operator Training Sessions:
   1. Prior to the startup of the new control system a training session shall be provided for all operators. The training session shall clearly explain how to utilize the new system. HMI

graphics for the new system shall be presented and operators shall have the opportunity to utilize the new system in a demonstration mode and navigate all the screens. The training session shall also explain and demonstrate customized features such as report generation, alarm review and acknowledgment procedures.

2. Two complete training sessions for all specified training shall be provided for the operators, one session for each shift.
3. Two months after the completion of the project a 4 hour refresher training session shall be provided to review the operations of the entire plant control system and answer any questions operators have developed on the system.
4. Eleven months after the completion of the project a 4 hour refresher training session shall be provided to review the operations of the entire plant control system and answer any questions operators have developed on the system.

D. Maintenance and Service Personnel Training:
   1. Prior to the startup of the new control system five days of hands on training sessions shall be provided for all maintenance and service personnel. The training session shall include the following:
      a. Clearly explain the architecture of the new system and explain how the network is configured and managed. Personnel shall be trained on network switch programming troubleshooting and available diagnostic tools.
      b. Cover all system software operation and configuration.
      c. Introduce basic PLC programming and explain methods for troubleshooting and identifying system issues.
      d. Cover system hardware and functionality.
      e. Cover database management and trending.
      f. Cover report template creation and report generation.
      g. Cover I/O database management and modifications including how points are added to the control system and managed.
      h. Cover PLC programming layout and logic associated with the plant. Programming logic shall be reviewed with the Owner and explanations shall be provided on programming methodologies and how the programs are organized and notated.
      i. Programming comments and documentation shall be reviewed with the Owner to provide a clear understanding of how the system functions.
      j. Additional topics as required to provide Owner with the ability to manage, troubleshoot, modify and maintain the plant control system.
   2. Eleven months after the completion of the project a two day refresher training session shall be provided to review all of the topics covered in the original training session and answer any questions personnel have developed.

E. Subcontractor shall record the training sessions and provide a final edited version to the Owner on a DVD-ROM and electronic video file format.

END OF SECTION 40 61 96

SECTION 40 66 00 – PROCESS CONTROL NETWORKS

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes network infrastructure, and ancillaries for process control networks and Supervisory Control and Data Acquisition (SCADA) systems.

B. Process control network shall not be connected to the internet and shall remain separate and unconnected from any Local Area Network (LAN) provided by the Owner.

C. This Section includes, but not limited to the following:

1. Fiber Optic Cabling, Termination and Accessories.
2. Fiber Optic patch panels and cables.
3. Network Cabling and Accessories.
4. Ethernet Switches.
5. Equipment Racks and Accessories.
6. Ethernet switches.

1.02 RELATED REQUIREMENTS:

A. Section 40 67 00 - Process Control Panels and Hardware

B. Section 40 68 00 - Process Control Software

1.03 REFERENCE STANDARDS:

A. Furnish equipment which conforms in all respects to applicable industry standards and sound engineer practice.

B. Design, fabricate, assemble, and test equipment so as to conform with the latest revision of all applicable codes and standards including, but not necessarily limited to, the following.

C. Electronic Components Industry Association (ECIA):

1. EIA/ECA-310-E – Cabinets, Racks, Panels, and Associated Equipment.

D. Institute of Electrical and Electronic Engineers (IEEE):

1. IEEE 802.1 – Local and Metropolitan Area Networks.
2. IEEE 802.3 – Ethernet.
3. IEEE 1613 – Environmental and Testing Requirements for Communications Networking Devices in Electric Power Substations.

E. National Electrical Manufacturer's Association (NEMA):

1. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum).

F. National Fire Protection Association (NFPA):

1. NFPA 70 – National Electrical Code.
2. NFPA 262 – Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.

G. Underwriter's Laboratories, Inc. (UL):

1. UL 44 – Thermoset-Insulated Wires and Cables.
2. UL 50 – Electrical Cabinets and Boxes.
3. UL 444 – Communications Cables.
4. UL 467 – Grounding and Bonding Equipment.
5. UL 514C – Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers.
6. UL 969 – Marking and Labeling Systems.
7. UL 1581 – Electrical Wires, Cables, and Flexible Cords.
8. UL 1863 – Communication Circuit Accessories.
9. UL 60950-1 – Information Technology Equipment - Safety - Part 1: General Requirements.

1.04 SUBMITTALS:

A. In addition to the requirements of SECTION 01 33 00, submittals shall include the following:
   1. Product Data:
      a. Data sheets for each cable type and equipment type specified.
      b. Cable manufacturer's approval of pulling compounds.
      c. Cable manufacturer's installation requirements such as maximum pulling tensions, sidewall pressures, minimum bending radii, reel dimensions, etc.
      d. Other ancillary equipment and materials to be used.
      e. Description of cable identification tags and attachment methods which will be used.

1.05 QUALITY ASSURANCE:

A. Materials and Equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of such products and shall be the manufacturer's latest standard design that has been in satisfactory use for at least 1 year prior to Bid opening. Each major component of the equipment shall have the manufacturer's name and type identified on the equipment. All products supplied shall be specifically designed and manufactured for use with plant communications systems. All items of the same class of equipment shall be the products of a single manufacturer unless indicated otherwise.

1.06 SITE CONDITIONS:

A. All Equipment provided as part of this system shall be rated for the temperature, seismic and elevations as specified in the Site Conditions in SECTION 26 00 00.

1.07 PERFORMANCE/DESIGN CRITERIA:

A. Materials and Designation: Refer to SECTION 26 00 00 for material service requirements, environmental ratings & hazardous locations.

1.08 WARRANTY:

A. The warranty shall comply with the requirements of SECTION 01 78 36.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

A. Provide to match existing system.
B. Fiber-Optic Cable Connectors, Duplex Jumpers, Patch Panels and Accessories:
   1. AFL.
   2. Avaya Inc.
   3. Black Box Corporation.
   4. Corning Optical Communications.
   5. Ortronics, Legrand.
   6. Panduit.
C. UTP Cables, Patch Panels, Connectors and Accessories:
   1. Belden.
   2. Berk-Tek, Nexans.
   3. Leviton.
   4. Mohawk, Belden.
   5. Ortronics, Legrand.
   6. Panduit.
   7. Siemon.

D. Equipment Racks:
   1. Black Box Corporation.
   2. B-Line, Eaton.
   3. Hoffman, Pentair Ltd.
   4. Lowell Manufacturing Company.
   5. Middle Atlantic Products, Legrand.
   6. Panduit.
   7. Contractor-approved equal.

E. Ethernet Switches:
   1. MOXA EDS-4008-LV.

F. Cable Accessories:
   1. Tape:
      a. Minnesota Mining and Manufacturing (3M).
   2. Cable Ties:
      a. AMP, TE Connectivity Ltd.
      b. IDEAL Industries, Inc.
      c. Minnesota Mining and Manufacturing (3M).
      d. Panduit.
      e. Thomas and Betts Corporation, ABB Group.
   3. Cable Supports:
      a. O-Z Gedney, Emerson Electric Co.

2.02 FIBER-OPTIC DUPLEX JUMPER/PATCH CORD:

A. Two-fiber cable with zipcord cable design, riser - rated (UL listed type OFNR).
B. Fiber shall be 62.5 µm, multimode, graded index.
C. Factory installed LC type connectors on each end of each fiber for patch through cables and connection to panel mounted Ethernet switches as required.
D. Factory installed LC type connectors on one end and LC type connectors on other end for connection to managed Ethernet switches as required.
E. Minimum length of 3 feet. Provide longer jumpers as required.
F. Provide patch cords as indicated plus 25% spare of each type.

2.03 UTP JUMPER/PATCH CORD:

A. Patch cords shall consist of factory assembled, 4 pair, 100 ohm UTP, Category 6 cables and equivalent eight-position, RJ-45 wiring connectors at each end.
B. Cables shall be wired with straight through pinning and shall be label verified.
C. Cable jacket shall be factory marked indicating organization and performance level.
D. Cable assemblies shall be designed with strain relief at each connector.
E. Cables shall be terminated according to type T568B configuration as defined by TIA-568-C.1.
F. Minimum length of 2 feet. Provide longer jumpers as required.
G. Provide patch cords as indicated plus 25% spare.
H. Cable shall comply with the applicable requirements of UL 444, UL 1685, UL 1863, and ANSI/TIA-568-C.2.
I. UTP patch cable specifications shall be as provided by the specification sheets at the end of this Section.

2.04 COMMUNICATIONS JACK/CONNECTOR ASSEMBLIES:

A. Copper jack/connectors shall comply with FCC Part 68.5, and TIA-568-C.2.

B. Shall be UL 1863 and UL 44 listed, non-keyed, 4 pair, constructed of high impact rated thermoplastic housing and shall be third party verified and shall comply with TIA-568-C.2 Category 6 requirements.
C. Shall meet or exceed Category 6 requirements.
D. Shall be terminated using a 110 style PC board connector, color coded for both T568A and T568B wiring.
E. Shall be wired T568B.
F. Shall comply with TIA-455-21A for 500 mating cycles.
G. Cover plates shall comply with UL 514C, and TIA-568-C.2; flush design constructed of 302 stainless steel material.
H. Stenciled lettering for voice and data circuits shall be provided using thermal ink transfer process.
I. Cover plates shall accept 4 Category 6 data jacks, or 4 RJ-45 telephone jacks, or a combination thereof.
J. Provide blank filler plates as required.

2.05 UTP PATCH PANELS:

A. Shall be a complete system of components by a single manufacturer, and shall provide termination, cable fastening, storage, and cross connection.
B. Utilize 110-style punch-down terminations on back of panel with individual retention caps. RJ-45 ports on front of unit.
C. Rear of panel shall have incoming cable strain relief and routing guides.
D. Shall meet or exceed TIA-568-C.2-1 Category 6 requirements. Each port shall be factory tested.
E. Wired to T568B configuration.
F. Shall be capable of terminating number of cables as indicated plus 25% spare capacity.
G. Shall be provided with labeling space, panel directory and warning labels.
H. Designed for installation within a 19-inch equipment rack.

2.06 EQUIPMENT RACKS:

A. Floor mounted enclosed style equipment rack. 19-inch (483 mm) standard designed complying with EIA/ECA-310-E.
B. Shall be a minimum of 42U of mounting units and shall be a minimum of 29-inches wide by 36-inches deep.
C. Load rated for a minimum of 1500 pounds.
D. Lockable perforated front door with reversible hinges.
E. Lockable, perforated, split rear door.
F. Removable solid side panels.
G. Louvered top panel with ventilation fans. Fans shall be provided with cord and plug and provide a minimum of 500 cfm of air flow. Provide plug and cord type thermostat controls with integral receptacle for fan plug connections.
H. Leveling feet.
I. Square hole mounting angles. Provide required cage nuts and bolts with a minimum of 25% spare.
J. Black powder coat finish.
K. Provide a vertical plug strip with NEMA 5-20R receptacles, 12-inches (300 mm) o.c. for the full height of the rack for each supplying circuit. Provide additional strips if required to accommodate all installed equipment plus 20% spare.
L. Provide grounding kit for each rack.

M. Provide horizontal cable managers below each patch panel and Ethernet switch.
N. Provide vertical D-rings or vertical cable troughs along each side for management of vertical routed cables.
O. Provide sliding shelves for monitors, keyboards, and other non-rack mountable equipment.
P. Provide all shelves, drawers, and accessories required for mounting and supporting equipment within the rack.

2.07 ETHERNET SWITCHES:

A. Provide the MOXA EDS-4008-LV.
B. Ethernet switches provided for the network shall be DIN rail mount hardened industrial Ethernet switches, capable of 10/100/1000 Mbps with autosensing and operate using the Store and Forward Method.
C. Switches must be managed type switches.
D. Unmanaged will not be accepted.
E. Capable of rapid spanning tree protocol (RSTP) or manufacturer's equivalent required for ring level topology in self-healing network.
F. Operating temperature 0°C to 60°C minimum.
G. Provide with redundant fan module for switch chassis when required to meet industrial environment ratings.
H. Ethernet switch shall be modular in design and accept Small form-factor pluggable (SFP) media modules.
I. Provide with required 10/100/1000 Base-T RJ-45 ports.
J. Shall provide half and full duplex operation.
K. LED indicators for system status, each power supply status, fault.
L. LED indicators for each port indicating link, activity, full/half duplex mode and speed.
M. Provide with a basic set of I/O parameters available via the Ethernet/IP protocol for device management and remote monitoring.
N. Comply with IEEE 802.1Q, 802.1D, 802.3, 802.3U, 802.3X, 802.3Z, and 802.3ab.
O. Capable of operating in a mesh network with rapid spanning tree protocol.
P. Shall support the following protocols or functions as minimum: SNMPv3, IGMP, DHCP, RMON, RSTP, HTTP, HTTPS, Telnet, and VLAN.
Q. Shall be UL listed and FCC approved. Unit shall be rated for continuous operation under the environmental temperature, humidity, and vibrating conditions encountered at the installed location.
R. Provide all required management and monitoring software.
S. Provide with redundant 120Vac, 60-hertz power supplies and cord and plug connection.
T. Provide with a minimum of two gigabit LC ports for connection to the fiber backbone.

2.08 ACCESSORIES:

A. Cable Supports:
   1. Cable supports for cables in vertical conduit risers or vertical tray, with considerable weight of cables shall be O. Z. Gedney Type "R" wedging plug type or approved equal.
B. Cable Ties:
   1. Shall be hook-and-loop (Velcro type) to meet EIA/TIA standards.
C. Cable Identification Tags:
   1. Refer to Section 26 05 53 – Electrical Identification for additional labeling requirements, including wire labeling format.
   2. Designed to provide a permanent wire and cable identification system.
   3. Show complete cable number including colors.

4. Cable numbers shall be machine printed, legible, and permanent.
5. Character size for cable numbers shall be a minimum of 1/8 inch.
6. Material shall be nonmetallic and impervious to moisture.
7. Be securely attached to cables and accessible for inspection.

PART 3 - EXECUTION

3.01 EXAMINATION:

A. Verify site conditions are suitable for installation of equipment. The area for network equipment installation shall be fully enclosed, weather tight, and free of contaminants.
B. Final or temporary HVAC systems shall be in place and operational to maintain the ambient temperatures and humidity conditions at occupancy levels prior to installation and shall be maintained for the remainder of the construction period.
C. Verify that all labels and nameplates meet UL 969 standards.
D. Any applicable equipment shall meet UL 60950-1.

3.02 INSTALLATION:

A. General:
   1. Cabling, connector assemblies, and associated hardware shall be installed in accordance with TIA 568 C.1, TIA 568 C.2, TIA-568-C.3, TIA 569 C, NFPA 70, and UL standards as applicable.
B. Cable:
   1. General Requirements:
      a. Metal raceway bases, covers, and dividers shall be bonded and grounded in accordance with TIA-607-B and UL 467.
      b. Install cable in raceway as indicated.
      c. Do not subject cable to pulling tensions or sidewall pressures in excess of manufacturer's recommendations.
      d. Subcontractor shall use a load rated swivel, rated to assure compliance with cable pulling tension as published by the cable manufacturer.
      e. Attach pulling grips around the cable diameter. Sufficient slack should be provided to cut off several meters of cable after it is in place.
      f. Do not subject cable to bending radius less than those recommended by the cable manufacturer.
      g. Support cables at connections or termination points such that any strain on cable will not be transmitted to the connection or termination.
      h. Install cable supports in vertical runs of conduit, at boxes and at terminations in equipment, and as required to meet intermediate support requirements of National Electrical Code (NEC).
      i. All pulling compounds shall be approved by cable manufacturer as being compatible with cable materials.
      j. Follow the cable numbering scheme indicated and attach a cable identification tag to each cable at all termination or end points.
   2. UTP Cable:
      a. Communications cabling and pathways with copper media shall be installed in accordance with the following criteria to avoid potential electromagnetic interference between power and communications equipment.
         (1) The interference ceiling shall not exceed 3.0 volts per meter measured over the usable bandwidth of the communications cabling.

(2) Pathways shall be installed in accordance with the following minimum clearance distances of 4 feet from motors, generators, frequency converters, transformers, or uninterruptible power system, 12 inches from power conduits and cable systems, 5 inches from fluorescent or high frequency lighting system fixtures.

b. Screw terminals shall not be used.

c. Use an approved insulation displacement connection (IDC) tool kit for copper cable terminations.

d. Do not untwist Category 6 UTP cables more than 1/2 inch from the point of termination to maintain cable geometry.

e. Provide service loop on each end of the cable, 10 feet at the equipment rack and 12 inches at the jack.

f. Do not exceed 25 pounds pull tension for four pair copper cables.

g. Do not chafe or damage outer jacket materials.

h. Do not over cinch cables, or crush cables with staples.

i. UTP cable bend radii shall not be less than four times the cable diameter.

3. Cable Connections and Terminations:

a. Subcontractor shall provide a qualified technician to make all connections and terminations cable as specified.

b. All cable connections and terminations shall be made according to manufacturer's instructions.

c. Make only in terminal boxes, equipment or other accepted enclosures and not in conduit or cable tray.

d. Install all connectors with manufacturer's approved tooling.

e. Cable identification markers shall be installed at each connection.

C. Equipment Racks:

1. Equipment racks shall be installed at location indicated. Verify proper clearances and adequate access prior to installation.
2. Install grounding kit and bond to building ground system.
3. Install cable management accessories and supports as specified.
4. Securely install equipment in racks as indicated. When required monitor and keyboard shelves shall be mounted at a convenient operating height.
5. Utilize manufacturer’s recommended fasteners for all connections.

D. Fiber Optic Patch Panels:

1. Install patch panels as indicated and specified.
2. Install panel mounted enclosures in NEMA rated enclosure or control panels as specified and indicated. For panels installed in equipment manufacturer’s control panels coordinate with supplier for required panel space and location.
3. Arrange with proper clearances from other equipment and material to obtain accessibility for operation and maintenance.
4. Install adaptor plates and connectors in accordance with manufacturer’s recommendations.
5. Utilize panel spools for slack management of individual fibers.
6. Mount plumb and level.
7. Complete panel directory and labeling.

E. UTP Patch Panels:

1. Install in equipment racks.
2. Punch down cables as specified.
3. Install cable strain relief and routing guides.

4. Wire to T568B configuration.
5. Complete port labeling.

F. Ethernet Switches:
1. Install Ethernet switches in equipment rack or control panels and make connections as indicated.
2. Arrange with proper clearances from other equipment and material to obtain accessibility for operation and maintenance.
3. Program managed switches for proper operations.
   a. Rapid spanning tree operation shall be implemented for redundancy in system.
   b. Program switch fault contacts to alert operators of switch problems or errors.
4. Manufacturer's management software shall be installed on the server, Workstation and laptop to allow the Owner to monitor and configure the Ethernet switches.

3.03 FIELD QUALITY CONTROL:

A. System Tests:
1. Perform communications cabling inspection, verification, and performance tests in accordance with TIA-568-C.0, TIA-568-C.1, TIA-568-B.2 and TIA-568-C.3.
2. Inspect all cabling terminations to confirm color code for tip and ring pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.2.
3. Perform optical fiber end to end attenuation tests using an optical light meter and manufacturer's recommended test procedures.
   a. Perform tests in accordance with TIA-526-14-B, Method B for horizontal, multimode optical fiber.
   b. Perform verification acceptance test on each fiber after installation of the cable.
   c. Any excessive losses due to installation, connectors, etc., shall be identified and corrected by the Subcontractor and tested with no additional charge.
4. Category 6 Links: Perform UTP link tests in accordance with TIA-568-C.2.
   a. Tests shall include wire map, length, attenuation, NEXT, and propagation delay.
5. After acceptance of communication cable system, all additional components (including Ethernet switches and jumpers) shall be installed and operation of the complete system tested.
6. Copies of the test shall be submitted to the Contractor for acceptance of the communication system.

3.04 ADJUSTING AND CLEANING:

A. All network cables shall be adjusted and neatly secured with tie wraps, hook-and-loop straps, or the like.
B. Prior to final acceptance all network equipment shall be wiped clean and free from dust.

3.05 TRAINING:

A. Provide a minimum of 4 hours of training at the customer's facility for operations, maintenance and service personnel of the installed network and SCADA radio system equipment.
1. The training session shall include classroom discussion on the theory of operation of the equipment, as well as maintenance and service methods for the purchased equipment.
2. Topics covered shall include hardware layout and functions, programming and configuration, diagnostic indicators, faults, diagnostic tools, troubleshooting, and preventive maintenance.
3. Hands-on training shall be provided on equipment.

4. Documentation shall be provided which shall include actual hard copies of manuals for the equipment supplied for this project.

B. Subcontractor shall record the training sessions and provide a final edited version to the Owner on a video DVD-ROM and electronic video file format.

END OF SECTION 40 66 00

SECTION 40 67 00 – PROCESS CONTROL PANELS AND HARDWARE

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes requirements for process control panels and internal components. Process control panels shall include:
   1. Process Control Panel Enclosure
   2. Thermal Management
   3. Nameplates
   4. Circuit Breakers
   5. Control Power Transformers
   6. Surge Protective Devices
   7. Terminal Blocks
   8. Switch Action Fuse Blocks
   9. Push Buttons and Selector Switches
   10. Pilot Lights
   11. Control Relays
   12. Time Delay Relays
   13. Intrinsically Safe Barriers
   14. Power Supplies
   15. Uninterruptable Power Supply (UPS)
   16. Convenience Receptacles
   17. Interior Illumination
   18. Ethernet Switches
   19. Programmable Logic Controllers (PLC)
   20. Operator Interface Terminal (OIT)

1.02 RELATED REQUIREMENTS:

A. Section 26 33 53 - Static Uninterruptible Power Supply
B. Section 26 43 13 - Surge Protection Devices for Low-Voltage Electrical Power Equipment.
C. Section 40 61 96 – Process Control System Programming and Reports.
D. Section 40 66 00 - Process Control Networks.
E. Section 40 68 00 - Process Control Software.

1.03 REFERENCE STANDARDS:

A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.
B. Institute of Electrical and Electronic Engineers (IEEE):
   1. IEEE 802.1 – Local and Metropolitan Area Networks.
   2. IEEE 802.3 – Ethernet.
C. National Fire Protection Association (NFPA):
   1. NFPA 70 – National Electrical Code (NEC).
   2. NFPA 79 – Electrical Standard for Industrial Machinery.
D. National Electrical Manufacturers Association (NEMA):
   1. NEMA 250 – Enclosures for Electrical Equipment (1,000V maximum).
   2. NEMA ICS 1 – Industrial Control and Systems - General Requirements.
   3. NEMA ICS 2 – Industrial Control and Systems - Controllers, Contactors, and Overload Relays Rated 600 Volts.
   4. NEMA ICS 4 – Application Guideline for Terminal Blocks.

5. NEMA ICS 5 – Industrial Control and Systems - Control Circuit and Pilot Devices.
6. NEMA ICS 6 – Industrial Control and Systems - Enclosures.

E. Underwriters Laboratories (UL):
1. UL 50 – Enclosures for Electrical Equipment.
2. UL 489 – Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures.
3. UL 508 – Industrial Control Equipment.
4. UL 508A – Industrial Control Panels.
5. UL 698A – Industrial Control Panels Relating to Hazardous (Classified) Locations.
6. UL 869A – Service Equipment.
7. UL 1449 – Surge Protective Devices.
8. UL 1778 – Uninterruptible Power Systems.

1.04 SUBMITTALS:

A. In addition to the requirements of SECTION 01 33 00, submittals shall include the following:
1. Product Data: Submit the following for each type of product specified:
a. Specification data sheets.
b. Catalog cut sheets.
c. Fabricator's qualifications.
2. Shop Drawings: Provide the following as minimum:
a. Fabrication drawings, front elevation, wiring diagrams, and bills of material for control panels.
b. General control panel arrangement drawings, front elevation, dimensions, wiring diagrams, and bill of materials.
c. Submit power and control wiring diagrams and schematics.
d. Wiring diagrams shall clearly indicate factory and field wiring with all termination locations clearly shown. All wiring shall be labeled and terminated on terminal blocks.
e. Interconnection diagrams showing conductor sizes, types, cable number, and wire color for all field connections. Clearly indicate which conductors are to be provided and installed by others.
f. Engraving schedule and physical dimensions for nameplates.
g. Provide heat dissipation calculations for all panels containing PLC components, remote-I/O components, or solid-state controllers. Include calculations for ventilation fans for environmentally controlled areas, or heat exchangers/air conditioners in process spaces or outdoors, if required.
h. Nameplate Data for all motors in accordance with NEMA MG 1 nameplate requirements.
i. Detailed control package summary including I/O lists, alarms, control loops, control schematics and integration of associated ancillary equipment. Control schematics shall provide all I/O requirements for motor control equipment provided by others.
3. Factory/Shop Test Plan:
a. Provide a complete and detailed test plan for the supplied control panels.
b. Include procedures for certification, validation, and testing.
4. Test and Evaluation Reports:
a. Factory test reports.
b. Field test reports.
5. Closeout Submittals: Final documentation shall include the following as minimum:
a. Operation and Maintenance Manuals including the following:
(1) Operation and maintenance manuals for all components furnished.

(2) Certified "As-Built"/"As-Installed" drawings.
(3) Copies of all approved Product Data.
(4) Copies of all approved Test Reports.
(5) Spare parts and supply list.
(6) Warranty Information.
(7) Subcontractor Information.

b. Training Materials.

1.05 QUALITY ASSURANCE:

A. As specified in SECTION 01 40 00.
B. Materials and Equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of such products and shall be the manufacturer's latest standard design that has been in satisfactory use for at least 1 year prior to Bid opening.
C. Fabricator Qualifications:
   1. Prior to assembly and installation, submit data of fabricator's experience and qualifications.
   2. Fabrication shall be by a manufacturer or a particular division of a manufacturing firm specializing in control panel construction.
   3. Shall have a minimum of 10 years' experience in control panel fabrication.
   4. Panel shall be fabricated in a UL listed panel shop.
D. Factory Tests:
   1. The manufacturer shall conduct tests according to industry standard requirements.
   2. Perform factory tests on all control panels and components and subassemblies to assure that all devices and systems are in proper working order before delivery to jobsite.
   3. Test all power, controls, full I/O test, and communication systems for proper operation.
   4. Simulate actual system operation.
   5. Submit test reports as specified in Division 01.
E. All control panels and associated equipment shall conform to the requirements of NEMA ICS and UL 508A standards.

1.06 DELIVERY, STORAGE, AND HANDLING:

A. As specified in SECTION 01 60 00.
B. Control panels and associate equipment shall be packaged and shipped to the project site in such a manner as to avoid damage.
C. All control panels shall be stored according to the manufacturer's instructions and in a conditioned space to avoid condensation, dust, and other environmental contaminants.

1.07 SITE CONDITIONS:

A. All Equipment provided as part of this system shall be rated for the temperature, seismic and elevations as specified in the Site Conditions in SECTION 26 00 00.

1.08 WARRANTY:

A. The warranty shall comply with the requirements of SECTION 01 78 36.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

A. Enclosures:
   1. B-Line, Eaton.
   2. Hoffman, Pentair PLC.

3. Wiegmann, Hubbell, Inc.
4. Milbank Manufacturing Company.
5. Saginaw Control & Engineering.

B. Classified Area Enclosures:
1. Appleton, Emerson Electric Company.
2. Killark, Hubbell, Inc

C. Thermal Management Components:
1. Hoffman, Pentair PLC.
2. Noren Products, Inc.
3. Pfannenberg.
4. Saginaw Control & Engineering.

D. Surge Protective Devices:
1. Advanced Protection Technologies, Inc.
2. Citel, Inc.
3. ASCO/EDCO, Vertiv Co.
4. Ferraz Shawmut, Mersen.
5. MCG Surge Protection, Inc.
6. MTL Instruments, Eaton.
7. Phoenix Contact.
8. Square-D, Schneider Electric.

E. Terminal Blocks:
1. Allen-Bradley, Rockwell Automation, Inc.
2. Buchanan, Tyco Electronics Corporation.
3. Phoenix Contact.
4. Square-D, Schneider Electric.
5. Weidmuller.

F. Push Buttons, Selector Switches and Pilot Lights:
1. Allen-Bradley, Rockwell Automation, Inc.
2. Appleton, Emerson Electric Company.
3. Eaton.
4. IDEC Corporation.
5. Killark, Hubbell, Inc.
6. Square-D, Schneider Electric.

G. Control and Timing Relays:
1. Phoenix Contact.
2. Allen-Bradley, Rockwell Automation, Inc.
3. Eaton.
4. IDEC Corporation.
5. Potter & Brumfield, Tyco Electronics Corporation.
6. Square-D, Schneider Electric.
7. Turck, Inc.

H. Intrinsically Safe Barriers:
1. MTL Instruments, Eaton.
2. Pepperl+Fuchs.
3. Square-D, Schneider Electric.
4. Turck, Inc.

I. DC Power Supplies:
1. Allen-Bradley, Rockwell Automation, Inc.
2. IDEC Corporation.
3. Phoenix Contact.

4. PULS.
5. SolaHD, Emerson Electric Company.

J. Uninterruptible Power Supplies (UPS):
1. Refer to Section 26 33 53 - Static Uninterruptible Power Supply

K. Convenience and UPS Receptacles:
1. Cooper Industries, Eaton.
2. Hubbell, Inc.
3. Leviton Manufacturing Co., Inc.
4. Phoenix Contact.

L. Interior Illumination:
1. Acuity Brands, Inc.
2. Hoffman, Pentair Inc.
3. Hubbell, Inc.
4. Stego, Inc.

M. Wiring Duct:
1. Panduit Corporation, H-Type.
2. Thomas and Betts Corporation, ABB Group.

N. Wire Markers:
1. Brady Worldwide, Inc.
2. Panduit Corporation.
3. Thomas and Betts Corporation, ABB Group.

O. Programmable Logic Controllers (PLC):
1. As specified for the Control System below.
2. Schneider Electrical Modicon M580 Series.

P. Operator Interface Terminal (OIT):
1. Schneider Electric
a. Screen: HMIDT642
b. OS Box: HMIG2U
c. Vijeo Designer 6.3

Q. Ethernet Switches:
1. As specified for the Control System below.
2. MOXA EDS-4008-LV

R. Variable Frequency Drives:
1. As specified for the Control System below.

2.02 PROCESS CONTROL PANEL ENCLOSURE:

A. Totally enclosed panel with gasketed doors, continuous hinge, and three point latching mechanism with lockable handle.

B. Sized to house all equipment and devices required, provide sufficient space for conduit entry, and provide sufficient heat dissipation for the installed components.

C. Provide separate 480V and low-voltage control panels to ensure operator safety.

D. Unless specified or indicated otherwise provide the following NEMA 250 approved enclosure type(s):
1. For the following areas:
a. Indoor electrical rooms: NEMA Type 12 gasketed painted steel enclosures.
(1) Painted enclosures shall have a light gray polyester powder coat finish on the exterior with a white polyester powder coat finish on the interior.
b. Indoor process areas: NEMA Type 4X stainless steel.
c. Outdoors: NEMA Type 4X stainless steel.

E. Unless specified or indicated otherwise provide the following enclosure design:

1. Wall Mount Design:
    a. Provide for enclosures with a vertical dimension less than 50-inches.
    b. Formed and welded construction, minimum 14-gauge.
    c. Interior 12-gauge minimum steel mounting panel(s).
    d. Provide mounting tabs and required hardware for installation of enclosures.
2. Free Standing and Floor Mount Design:
    a. Provide for enclosures with vertical dimensions of 50-inches or greater.
    b. Formed and welded construction, minimum 12-gauge for single door enclosures. For multi-door enclosures provide a 10-gauge back.
    c. Interior 10 or 12-gauge steel mounting panel(s).
    d. Provide door mounted folding shelf for support of instruments and test equipment. Shelf shall be mounted on the interior of the door. For multi-door enclosures provide a shelf for each pair of doors.
    e. Provide with lifting eyes.

F. Provide lockable design with IL-101 lockable handle and key.
G. Provide convenience receptacle as specified this Section.
H. Provide Thermal management as specified this Section.
I. Provide LED light with door switch as specified this Section.
J. Accessories:
1. Provide data pocket mounted on the interior of the panel for storage of wiring diagrams.
2. Provide a door stop kit designed to secure the door in the 90 degree open position.
K. Shall comply with UL 50, UL 508A, and NEMA ICS 6 standards.

2.03 THERMAL MANAGEMENT:

A. Provide as required to maintain panel temperature below component ratings.
B. Provide for the following panels:
1. Panels with PLCs installed.
2. Panels with VFDs installed.
C. Provide a compact 6-inch fan with rigid metal housing with finger guard. Motor shall be thermally protected and bearings shall be permanently lubricated ball bearings and design for a minimum of 50,000 hours of continuous operation. Impeller shall be polycarbonate. Powered from 120Vac.
D. Provide 14-gauge steel louver for the intake and exhaust openings. Louver finish shall match the finish on the panel. Provide an aluminum filter and gasket for each louver.
E. Provide all required mounting brackets for complete installation in the panel.
F. Temperature Switches:
1. Provide single pole double throw (SPDT) temperature switch for each panel, wire the normally open (NO) contacts to the exhaust fan, and the normally closed contacts to the PLC high temperature alarm as indicated.
2. The temperature control switches shall have an adjustable range of 30°F to 140°F.
3. The temperature switch contact shall close on temperature rise and be rated 15A at 120Vac.
4. Designed for DIN rail mounting.
5. The high temperature alarm switch shall be set at 100°F and the fan switch shall be set at 80°F.
6. Prewire high temperature alarm switch to a PLC digital input.
G. Panel Heater:
1. Each control panel shall be equipped with a convection-type panel heater.
2. Control of the heater shall be performed by the thermostat.

3. The thermostat shall be set to energize the heater when the temperature falls below an adjustable setpoint. The initial setpoint shall be 40°F.

H. Closed-Loop Air Conditioning System:
1. Provide a closed-loop mechanical refrigeration air conditioning system.
2. The air conditioning system shall be selected to maintain the NEMA rating of the enclosure. The construction material shall match the associated panel.
3. The system shall be capable of maintaining a temperature of 85°F inside the enclosure under the following conditions:
   a. All equipment in the panel operating.
   b. Continuous exposure to sunlight.
   c. Exterior ambient air temperature of 104°F.
4. The compressor and condenser shall be located outside the control panel enclosure.
5. Provisions shall be made to remove condensate from the control panel and to protect all devices within the enclosure from condensate.

6. Manufacturer shall submit sizing calculations for each panel listed above.

2.04 NAMEPLATES:

A. Fabricate from laminated phenolic sheeting with black core and satin finish melamine overlay.
B. Colors shall white with black letters.
C. Thickness: 1/16 inch nominal.
D. Bevel edges to expose black core on perimeter.
E. Engraved legend through overlay to expose core.
F. Attach to panels with industrial grade double-faced tape.
G. Refer to SECTION 26 05 53 – Electrical Identification for additional labeling requirements.

2.05 CIRCUIT BREAKERS:

A. Provide for main disconnecting means for panel and for power distribution within the panel for all voltages.
1. 480Vac:
   a. Protective devices shall be molded case circuit breakers with thermal-magnetic trip units and inverse time and instantaneous tripping characteristics.
   b. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position.
   c. Circuit breakers shall have a symmetrical interrupting capacity AIC rating matching the power panel supplying power, refer to Power Panel Schedules, and a minimum rating of 18,000 AIC or available fault current whichever is greater.
   d. Main circuit breakers shall be provided with a door interlocked remote operator kit suitable for installation in provided enclosure. The main disconnect shall be lockable in the off position.
   e. Number of poles and ampere rating as required.
2. 120/240Vac and 24Vdc:
   (1) Rated for 120/240Vac and 24Vdc as indicated.
   b. Thermal-magnetic trip units.
   c. Trip rating and curve as recommended by manufacturer of equipment being protected.
   d. DIN rail mounted on the inside of the control panel in a readily accessible location.
   e. Toggle-type handle with a quick-make, quick-break over-center switching mechanism that is mechanically trip-free.

3. Minimum symmetrical interrupting capacity of 10,000 AIC or available fault current which ever is greater.

B. All circuit breakers must be UL 489 listed.

2.06 CONTROL POWER TRANSFORMERS:

A. Control Panels shall be provided with control power transformers. Refer to SECTION 26 22 13 – Low Voltage Distribution Transformers for requirements.

2.07 SURGE PROTECTIVE DEVICES (SPD):

A. Control Panels shall be provided with an integral Surge Protective Device (SPD). Refer to SECTION 26 43 13 – Surge Protection Devices for Low-Voltage Electrical Power Equipment for requirements.

2.08 TERMINAL BLOCKS:

A. 600V, sectional type polyamide blocks.
B. Rated a minimum of 24A. Provide higher Amp rated blocks as required.
C. Screw connection type.
D. Finger safe.
E. Slide in vinyl marking strip for terminal identification.
F. DIN rail mounted.
G. Terminal blocks shall comply with NEMA ICS 4.

2.09 SWITCH ACTION FUSE BLOCKS:

A. Rated 600V.
B. Screw connection type.
C. Finger safe.
D. DIN Rail mounted.

2.10 PUSH BUTTONS AND SELECTOR SWITCHES:

A. Heavy duty, 30 mm units with contacts rated 10A continuous at 120Vac.
B. NEMA 4X rated when installed in NEMA 12 or 4X enclosures.
C. Provide the number of contacts and contact development as indicated.
D. Operator colors shall comply with UL 508A and NFPA 79.
   1. Start or On push buttons shall have green operators.
   2. Stop or Off push buttons shall have red operators.
E. Emergency Stop push buttons shall have red mushroom head operators with a yellow base.
F. Provide hermetically sealed units when installed within a classified area.
   1. Suitable for installation in a Class I, Division 1 and 2, Group D area.
G. Push Buttons and Selector Switches shall conform to NEMA ICS 5.

2.11 PILOT LIGHTS:

A. Heavy duty, 30 mm units.
B. NEMA 4X rated when installed in NEMA 12 or 4X enclosures.
C. 120Vac or 24Vdc cluster LED type.
D. Green lights shall indicate “Equipment On”, “Running”, or “Valve Open”.
E. Red lights shall indicate “Equipment Off”, “Stopped”, or “Valve Closed”.
F. Amber lights shall indicate “Equipment Failure” or “Alarm”.
G. Blue lights shall indicate “Equipment in Auto”.
H. Push-to-test type.
I. Pilot lights shall conform to NEMA ICS 5.

2.12 CONTROL RELAYS:

A. Plug-in type relay with neon coil energization indicator.
B. Coil voltage: 120Vac or 24Vdc as required.
C. Contacts rated 10 Amps at 120Vac.
D. Number of contacts as required.
   1. Provide one spare N.O. and one spare N.C. contact (minimum).
   2. Spare contacts shall be as indicated.
E. Provide DIN rail mounted relay socket with screw type terminations.
F. Control relays shall conform to NEMA ICS 5.

2.13 TIME DELAY RELAYS:

A. Plug-in type digital based electronic timing relay with coil energization indicator.
B. Coil voltage: 120Vac or 24Vdc as required.
C. Contacts rated 10 Amps at 120Vac.
D. Timing range as indicated with a minimum setting accuracy of ±2% and repeat accuracy of ±0.1%.
E. The selection of timing range settings via DIP switches. The time delay within the range shall be set utilizing an adjustment dial.
F. Number of contacts as required.
   1. Provide one spare N.O. and one spare N.C. contact (minimum).
G. Provide DIN rail mounted relay socket with screw type terminations.
H. Time delay relays shall conform to NEMA ICS 5.

2.14 INTRINSICALLY SAFE BARRIERS:

A. Intrinsically Safe Barrier Relays:
   1. Supply voltage 120Vac.
   2. Approved intrinsically safe for Class 1, Division 1, Group D areas.
   3. Accept a dry contact input.
   4. Two SPDT relay outputs rated 5A at 120Vac.
   5. LED indication of relay state.
B. Intrinsically Safe Barrier Transmitters:
   1. 24Vdc regulated power supply input.
   2. 2 wire, 4-20mA transmitter type.
   3. 4-20mA safe area output.
   4. Approved intrinsically safe for Class 1, Division 1, Group D areas.

2.15 DC POWER SUPPLIES:

A. Provide industrial rated primary switched 24Vdc power supplies as specified and indicated.
B. Enclosed design with finger safe input and output terminal blocks.
C. Designed for DIN rail or back panel mounting.
D. DC power supply rated as follows:
   1. Input voltage: 95 to 130Vac.
   2. Output voltage: 24Vdc ±1%.
   3. Output current: 10A minimum with a minimum 25% spare capacity.
   4. Line regulation: ±0.2% maximum.
   5. Load regulation: ±1.5% maximum.
   6. Ripple: <50 mV pk-pk.
   7. No overshoot for turn on, turn off, or power failure.
   8. Operating temperature: -25°C to +60°C.
   9. Overload and short circuit protection.

10. Indicating lights for status.

E. Redundancy Module.
   1. Provide DIN rail mounted redundancy module that provides complete isolation between two 24Vdc power supplies.
   2. Unit shall accept two 24Vdc inputs and provide one redundant 24Vdc output.
   3. Rated for a minimum of two 20A inputs and one 20A output.
   4. Operating temperature: -25°C to +60°C.
   5. Provide status light and dry output contact that opens when either of the 24Vdc inputs is lost. Output contact shall be rated a minimum of 2 Amps at 30Vdc.

2.16 UPS (LINE INTERACTIVE):

A. Network grade, uninterruptible power system completely self-contained module with an inverter, batteries and control system as specified in Section 26 33 53.
B. Shall be provided for PLC Cabinets and other control panels containing micro-processor based controllers.
C. Electrical Capacity: 1500VA minimum.
D. Provide all required mounting hardware to mount the panel on a shelf within the PLC panel.
E. Provide three ½ amp fused terminals for 120 VAC UPS power to be wired by others to field devices.

2.17 CONVENIENCE RECEPTACLES:

A. Interior Mounted Receptacle:
   1. DIN rail mounted, 15-A duplex three-wire grounding GFCI type receptacle with enclosure.
   2. Equipped with terminal blocks for power connection.
   3. Outlet shall be protected with a 5 Amp circuit breaker.
   4. One mounted inside control panel for use in powering laptops and test equipment for service of the panel.
B. Door Mounted Receptacle:
   1. Interior PLC Control Panels shall include a door mounted combination power receptacle and data port to allow access to devices inside without opening the enclosure door.
   2. The receptacle shall be a 15-A duplex three-wire grounding GFCI type. The receptacle shall be equipped with terminal blocks for power connection. The receptacle shall be protected with a 5 Amp circuit breaker.
      a. The receptacle shall be sourced from the control panel 120Vac UPS unit.

2.18 INTERIOR ILLUMINATION:

A. Provide LED type panel lights.
B. Minimum 50,000 hour life.
C. Size and quantity designed to provide a minimum 50 foot-candles at the base of the panel.
D. Powered from 120Vac. Provide required power supply.
E. Panel light shall be controlled by a door interlock switch.

2.19 POWER DISTRIBUTION:

A. Wiring:
   1. UL style 1015 (AWM), or UL style 1063 machine tool wire (MTW), 600V, 90°C.
   2. No. 14 AWG (minimum), 41 strand, for all control wiring.
   3. No. 18 AWG (minimum), shielded twisted pairs and triads as applicable for all instrumentation wiring.
      a. Color code shall be black/red pair (black/red/white triad) with black PVC jacket.

4. Wire Colors (UL508A):
    a. Black: 240V or 480V AC wiring.
    b. Red: 120V AC wiring.
    c. White: AC neutral.
    d. Green: Ground.
    e. Blue: DC(+).
    f. White w/ Blue Tracer: DC(-) grounded.
    g. From alternate power source that remains energized when main disconnect is open:
        (1) Yellow: Un-switched power.
        (2) White w/Yellow Tracer: Un-switched neutral.

B. Wire Markers:
1. Heat shrinkable, tube-type sleeve markers, constructed of polyolefin material.
2. White sleeves with black thermal printed text.
3. Identify both ends of wire with the same unique wire number.
4. Assign wire numbers where specific designations are not indicated.
5. Markers sized for snug fit for wire size.

C. Wiring Duct:
1. Provide wide slot wiring duct in panel for routing of panel wiring. Slots shall be a minimum of 0.25-inches.
2. Provide with dual hinge, push-on cover that opens a minimum of 100 degrees to either side.
3. Wiring ducts shall be sized to accommodate all installed wire plus a minimum of 25% spare capacity.

D. Ground Bus:
1. Provide copper ground bus for power circuits.
2. Provide isolated copper ground bus for instrument shields.

2.20 ARC FLASH LABEL:

A. Provide a 6 x 4 inch (minimum), plastic arc flash label for each control panel.
B. Label shall be orange and white.
C. Label shall read as follows: WARNING – Arc Flash and Shock Hazard. Appropriate PPE and Tools Required When Working on this Equipment.
D. Coordinate with Section 26 05 73 – Electrical Studies.

2.21 SPARE PARTS:

A. Two spare LED indicating lamps for each type and color used.
B. Two spare indicating light assemblies.
C. Ten spare control fuses of each voltage and current rating used.
D. One aerosol cans of manufacturer's touch-up paint for each color used. Color shall match the original factory applied color.
E. Provide ten (10) spare fuses of each type used including those used in power supplies, processor and all I/O cards.

2.22 PROGRAMMABLE LOGIC CONTROLLERS (PLC):

A. Provide SPD in process control panels on main power feed for all PLCs installations.
B. All PLC's including vendor supplied panels shall be SE M580 platform.
C. All analog inputs and outputs shall be individually fused.
D. All digital inputs and outputs shall be individually fused.
E. Provide PLC hardware.
1. General:

a. The programmable controller shall receive status intelligence, perform logic functions, issue control commands, and provide alarms and status information for the systems described in these Specifications.
b. The programmable controller Equipment shall consist of a solid-state control system which has user programmable memory for storage of instructions to implement specific functions.
c. The PLC Equipment shall be purposely designed as an industrial control system which can perform functions equivalent to a relay panel or a wired solid-state logic system.
d. Maximum scan time of 25 ms for all channels.
e. All PLC Equipment provided shall be capable of operation in ambient temperatures of 0°C to 60°C, and 5 to 95% relative humidity (non-condensing), without fans or other cooling equipment.
f. All external connection points shall be capable withstanding the IEEE surge withstand capability (SWC) test as defined in IEEE C37.90.1.
g. The PLC's shall be capable of being configured as a redundant controller.

2. Chassis:
   a. Provide PLC chassis as required to accommodate the I/O and communications modules required and indicated.
   b. Provide slot fillers for all unused chassis spaces.
3. Power Supplies:
   a. Provide power supplies for the processor chassis and expansion chassis as required.
   b. Power supply shall be sized to supply required power for all installed modules and any spare spaces within the chassis.
   c. Input voltage shall be 120Vac as indicated.
4. Processor:
   a. The processor shall be of solid-state design on modular printed circuit boards.
   b. The processor shall be equipped with an additional communications port for programming.
   c. The processor shall have user-programmable memory with provisions to prevent unauthorized changes.
   d. The processor shall continuously perform diagnostics analysis with a predetermined failure mode in the event of a fault.
   e. All I/O including analog shall be scanned and updated at a rate not to exceed 0.3 milliseconds per scan.
   f. The processor shall allow the logic to be modified, while the processor is in the Run mode without affecting the operation of those portions of the logic not being modified.
   g. The processor shall provide selectable timed interrupt capabilities for the user to incorporate into the running code.
   h. The processor shall provide user defined fault routine capabilities.
   i. The processor shall automatically clear all output and update all input on power-up and prior to scanning and solving any logic.
   j. The processor shall provide the user with a status bit for use in the logic for initialization purposes. This status bit shall be set/reset based on the indicating the first program scan.
   k. The processor shall provide a comprehensive instruction set including:
      (1) Relay Contact Input:
         (a) Normally open.
         (b) Normally closed.

(c) Transitional.

(2) Relay Coil Output:
(a) Standard.
(b) Retentive.

(3) Timers:
(a) On delay.
(b) Off delay.
(c) Duration.
(d) Retentive
(e) Time bases of 1.0 sec, 0.1 sec, and 0.01 sec.

(4) Counters:
(a) Count up.
(b) Count down.

(5) Arithmetic:
(a) Single-precision.
(b) Double-precision.
(c) Integer.
(d) Add.
(e) Subtract.
(f) Multiply.
(g) Divide.
(h) Square root.
(i) Less than.
(j) Greater than.
(k) Equal.

(6) Logical:
(a) And.
(b) Or.
(c) Exclusive or.
(d) Compare.

(7) PID.

5. Communications Hardware:
   a. Provide communication modules for communications via the communications network.
      (1) All data within a PLC shall be accessible to any operator workstation, PLC or OIT.
         (a) Programming functions shall be possible over the network.
         (b) Unloading and downloading of programs shall be possible over the network.
         (c) The operating mode of the PLC shall be changeable via the network.
   b. Provide all required communication cables, connectors, and terminating resistors.
6. PLC Input and Output Modules:
   a. Digital Input Modules:
      (1) 120Vac nominal input voltage with an on state voltage of 79 to 132Vac and an off state voltage less than 20Vac.
      (2) Maximum hardware input delay time of 10 ms.
      (3) Maximum inrush current of 0.25 Amps.
   b. Relay Output Modules:
      (1) Rated 2.0 Amps nominal at 120Vac.
      (2) Maximum output delay time of 13 ms.

(3) Make rating of 15 Amps and a break rating of 1.5 Amps at 120Vac.
(4) Provide individual surge suppressors for each output to protect module from surges caused by inductive load switching.

c. Analog Input Modules:
(1) Individually isolated, 4-20 mA current inputs.
(2) Each input shall have a minimum 16-bit resolution.
(3) Programmable input filter.

d. Analog Output Modules:
(1) Individually isolated, 4-20 mA current outputs.
(2) Each output shall have a minimum 16-bit current resolution.
(3) Provide 1700Vdc channel to channel isolation and channel to backplane isolation.

e. Provide screw clamp removable terminal block connectors for each module.

2.23 OPERATOR INTERFACE TERMINAL (OIT):

A. Provide Schneider Electric, Harmony GTU model HMIDT642 with associated OS Box model HMIG2U. Confirm models meet the space rating they are to be installed within. Coordinate alternatives with the Owner.
B. Provide in accordance with the software the Owner has license for, Schneider Electric HMI with Vijeo Designer 6.3.
C. Provide for process control panels and vendor supplied control panels.
D. Provide a 12.1" capacitive touch flat glass panel color TFT LED display. Resolution shall be 1024x768 XGA (4:3 ratio), minimum.
E. Luminance shall be a minimum of 1000 cd/m2 (Nits) LED backlight.
F. Operating systems shall be Vijeo OS, compatible with owner's current standards. Windows is not acceptable by the owner.
G. CPU shall be RISC 600MHz.
H. 1 GB storage. Expandable via SD card or USB flash memory.
I. 256 MB RAM.
J. Built-in functional isolation for power and serial communication channels
K. Environmental operating temperature range shall be -20° to 60°C, at 5 to 85% non-condensing relative humidity.
L. Shall be panel mounted with a NEMA rating to match the associated enclosure rating.
1. Provide with cover or exterior door to protect the screen from elements/security/
M. Provide the following external ports and interfaces as minimum:
1. One SD Card.
2. A minimum of 2 USB-2.0 host ports for peripheral connections.
3. 1 RS-232/485/422 configurable port
4. 2 expansion slots
N. Communication interfaces shall include the following:
1. Two RJ-45 Ethernet (1 - 10/100/1000 Mb Autosensing, 2 – 10/100 Mb Autosensing).
O. Shall accept input power from 24VDC, 1A max. Provide DIN-rail 120Vac AC-to-DC power supply as required.
P. IP66 front, IP20 rear. Provide conformal coating when located in process space or outdoors.
Q. UL Class 1 Div 2 rated.
R. Shall be capable of communicating over the Control system network as indicated.

2.24 ETHERNET SWITCHES:

A. Refer to Specification 40 66 00.

PART 3 - EXECUTION

3.01 EXAMINATION:

A. Verify site conditions are suitable for installation of equipment.

B. For indoor control panels final or temporary HVAC systems shall be in place and operational to maintain the ambient temperatures and humidity conditions at occupancy levels prior to energizing panel and shall be maintained for the remainder of the construction period.

3.02 PANEL FABRICATION:

A. Install all components in the panel as required and recommended by the manufacturer.

B. Provide master nameplate and nameplates for all operator interfaces. Interior nameplates shall be provided for individual component identification including, but not limited to, power supplies, PLCs, control relays, terminal blocks, Ethernet switches, circuit breakers, etc.

C. Provide interior illumination for all panels.

D. Power Distribution:

1. Provide circuit breakers for protection of equipment in the panel and distribution of power to equipment powered from the control panel.
2. Provide main power disconnect operable from the exterior of the panel for all panels supplied with 480-volts. For panel supplied with 480-volt power provide properly sized control power transformer and required circuit breakers for distribution of power within the panel. Provide dedicated circuit breakers for all 480-volt equipment powered from the panel.

1. Control panels shall include provisions for connection of a 120Vac, 20Amp supply.
   a. Control panels served by a panel mounted UPS shall include provisions for connection of two (2) 120Vac, 20Amp supply circuits. One circuit shall be used as "House" power for lights, fans, receptacles, etc. The second circuit shall power the panel mounted UPS and shall power all PLC, network, and control system related loads.
2. Provide 120Vac circuit breakers to distribute power within the control panel. Circuit breakers shall be sized based upon connected load. As a minimum, a dedicated circuit breaker shall be provided for the each of the following:
   a. Incoming power sources.
   b. UPS power source.
   c. Each device such as lights, fans, heaters, receptacles installed within the panel.
   d. 24Vdc power supplies.
   e. Each 120Vac digital input or output module.
   f. Each 120Vac instrument or device powered from the panel.
3. Provide 24Vdc circuit breakers to distribute power within the control panel. Circuit breakers shall be sized based upon connected load. As a minimum, a dedicated circuit breaker shall be provided for each of the following:
   a. Output of 24Vdc power supply.
   b. PLC power supply (24Vdc).
   c. Each 24Vdc digital input or output module.
   d. Each loop powered instrument.
   e. Each analog input module, if required.
   f. Each analog output module, if required.
   g. Each 24Vdc instrument or device powered from the panel.
4. Provide signage on panel to clearly indicate that the panel is powered from multiple sources if applicable.

E. Surge Protection:
   1. Provide surge protection on the incoming 480Vac supply and 120Vac distribution systems within the panel to protect electronic components from transient voltage surges.
   2. Provide surge protection on all power circuits to instruments installed outside. The terminal block type surge suppressor shall be the termination point for the field cabling.
   3. Provide surge protection on all inputs and outputs that are connected to equipment including copper network cables located outside. The terminal block type surge suppressor shall be the termination point for the field cabling.

F. Component Mounting:
   1. Operator interfaces and indicating lights shall be installed in the door of the panel at a convenient height for operator interaction.
   2. Components shall be mounted to provide complete accessibility to all terminals, relay sockets, and other devices without dismantling of panel equipment.
   3. Provide sufficient space around and layout components to allow for proper heat dissipation.
   4. Provide sufficient space at the top and bottom of the panel for conduits and cable entry. Conduit entry locations shall be coordinated with the Subcontractor.

G. PLC I/O:
   1. Provide interposing relays for all discrete outputs from the PLC including spare points.
   2. Provide interposing relays for all relay outputs from the PLC driving loads that exceed 1.5A and when indicated.
   3. Wire all inputs and outputs from the PLC to terminal blocks.

H. Wiring Methods:
   1. Route main groups of wires in plastic nonflammable wiring duct.
   2. Smaller groups of wire shall be cabled and secured with nylon cable clamps and ties or plastic spiral wraps.
   3. Maintain physical separation of power, control and instrumentation cables within the panel.
   4. Provide dedicated wiring ducts for management of field cables within the panel. Wiring ducts shall be sized to accommodate multi-conductor control cables. Assume a minimum of 25% spare conductors and provide a minimum of 25% spare capacity when sizing wiring ducts.

I. Terminal Blocks and Connections:
   1. Provide terminal blocks for all external connections.
   2. Make all connections on terminal blocks.
   3. Follow manufacturer's recommendations for terminal block installation.
   4. Connect terminal blocks for instrumentation cable shields to isolated ground bus.
   5. Provide required grounding type terminal blocks.

J. Spare Capacity:
   1. Provide a minimum of 25 percent, or 2 circuit breakers, whichever is greater, for each power source (Vac and Vdc) present within the panel. All spare circuit breakers shall be mounted, wired, and include provisions to terminate associated neutral or negative conductors.
   2. Provide a minimum of 4 spare slots in each PLC chassis. Provide blank filler modules for all empty slots.
   3. Provide a minimum of 20 percent or 4 points, whichever is greater, spare PLC inputs and outputs for each I/O type in each panel. All spare points shall be wired to field terminal blocks. Fifty percent of spare analog inputs shall be configured to provide loop power.
   4. Provide a minimum of 20 percent spare terminal blocks of each type mounted in the panel.

5. Provide spare DIN rail space for the installation of terminal blocks for all spare slots in the PLC chassis.

K. Provide labeling on all terminal blocks, wiring and relays to match panel drawings.

3.03 UNINTERRUPTIBLE POWER SUPPLY INSTALLATION:

A. Refer to Specification 26 33 53 – Static Uninterruptible Power Supply.
B. Install UPS systems in control panel as specified.
C. Startup and initial charging shall be as required by the UPS manufacturer.
D. Install the Maintenance Bypass Switch and make the required connections to UPS and loads served.

3.04 ETHERNET SWITCH INSTALLATION:

A. Refer to Specification 40 66 00 – Process Control Networks.
B. Install Ethernet switches in control panels and make connections as indicated.
C. Arrange with proper clearances from other equipment and material to obtain accessibility for operation and maintenance.
D. Shall provide adequate ports for connection to the plant control system, PLC, OIT, door mounted RJ-45 port, and provide a minimum of one spare programming port.

3.05 PLC PROGRAMMING:

A. Refer to Section 40 61 96 – Process Control Software Programming and Reports for PLC programming requirements.

3.06 OIT PROGRAMMING:

A. Refer to Section 40 68 00 for OIT and graphic programing requirements.

3.07 INSTALLATION:

A. Control Panels:
   1. Conform to manufacturer's written instructions.
   2. Surface-mount wall mount enclosures on structural supports or wall approximately 4 feet to center line above the floor when possible.
   3. Install floor mounted enclosures where indicated and bolt to floor using expansion type concrete anchors.
   4. Install all necessary openings in panels.
   5. Arrange with proper clearances from other equipment and material to obtain accessibility for operation and maintenance.
   6. Mount plumb and level.
B. Electrical Connections:
   1. Install wire and cable as specified in Division 26.
   2. Conform to manufacturer's wiring diagrams.
   3. Install circuits to field-mounted equipment as indicated and required.
   4. Installation shall conform to NFPA 70 (NEC).
C. Place arc flash label on equipment.

3.08 FIELD QUALITY CONTROL:

A. Manufacturer's Field Services:
   1. The panel supplier shall provide the field services of a trained technician for the amount of time required to commission, test and start-up all equipment provided.

2. All travel and living expenses shall be included for all trips to the site. All equipment required for testing, start-up and performance verification shall be provided by the start-up technician.

B. Check all internal and external connections and tighten as required.
C. Perform I/O checkout on all points and verify proper operation.
D. Verify proper connection of communication cabling and proper communication system configuration.
E. Field verify proper operation of all inputs and outputs.
F. Record results of I/O checkout and submit test reports as specified in Division 01.

3.09 FINISHES:

A. Control panel coatings shall be free from scratches, rust, or other defects.
B. All damaged or defective coatings shall be repaired prior to final acceptance.
C. Field Painting:
   1. Touch Up:
      a. Subcontractor shall prepare surfaces and touch up manufacturer applied coatings as required for any damage during shipment and installation.
      b. Field painting shall be performed based on manufacturer's recommended procedures.
      c. Subcontractor shall provide the necessary quantity of Manufacturer's touch-up paint to match the factory applied finish.

3.10 ADJUSTING AND CLEANING:

A. After field installation and final wiring terminations are completed the control panel wiring and cables shall be adjusted and neatly secured with tie wraps, hook-and-loop straps, or the like.
B. Wiring duct covers shall be replaced and secured as required.
C. Prior to final acceptance control panel interior and exterior shall be wiped clean and free from dust and debris.

3.11 TRAINING:

A. Provide a minimum of 4 hours of training for each panel provided at the customer's facility for operations, maintenance and service personnel.
   1. The training session shall include classroom discussion on the theory of operation of the equipment, as well as maintenance and service methods for the purchased equipment.
   2. Topics covered shall include safety, hardware layout and functions, power and control wiring, diagnostic indicators, keypad/display interface, faults, diagnostic tools, troubleshooting, and preventive maintenance.
   3. Hands-on training shall be provided on equipment.
   4. Documentation shall be provided which shall include actual manuals for the equipment and drawings and schematics of equipment supplied for this project.
B. Subcontractor shall record the training sessions and provide a final edited version to the Owner on a video DVD-ROM and electronic video file format.

END OF SECTION 40 67 00

ATTACHMENT

I/O LIST

Complete Tag	DESCRIPTION	Signal Type	Signal Level	Power Source	Controlled By	Description "0" Level	Description "1" Level	P&ID Drawing
AI-191-TSS	POND CONCRETE OVERFLOW TSS ANALYZER INDICATION	AI	4-20mA	LP-1	CP-100	N/A	N/A	1I-602
AI-192-CL	POND CONCRETE OVERFLOW CHLORINE ANALYZER INDICATION	AI	4-20mA	LP-1	CP-100	N/A	N/A	1I-602
SE-132-ROT	PAC SYSTEM ARCH BREAKER ROTATION SENSOR	DI	120VAC	PAC-PLC	PAC-PLC	N-FAULT	FAULT	1I-601
YA-132-OL	PAC SYSTEM ARCH BREAKER THERMAL OVERLOAD	DI	120VAC	PAC-PLC	PAC-PLC	N-OVERLOAD	OVERLOAD	1I-601
YS-132-RC	PAC SYSTEM ARCH BREAKER START/RUN COMMAND	DO	120VAC	PAC-PLC	PAC-PLC	STOPPED	RUN	1I-601
SE-133-ROT	PAC SYSTEM SCREW FEEDER TRAIN A ROTATION SENSOR	DI	120VAC	PAC-PLC	PAC-PLC	N-FAULT	FAULT	1I-601
YS-133-RC	PAC SYSTEM SCREW FEEDER TRAIN A VFD RUN COMMAND	DO	120VAC	PAC-PLC	PAC-PLC	STOPPED	RUN	1I-601
SC-133	PAC SYSTEM SCREW FEEDER TRAIN A VFD SPEED/CURRENT FEEDBACK	AO	4-20mA	PAC-PLC	PAC-PLC	N/A	N/A	1I-601
SI-133	PAC SYSTEM SCREW FEEDER TRAIN A VFD SPEED REFERENCE	AI	4-20mA	PAC-PLC	PAC-PLC	N/A	N/A	1I-601
YA-133-FLT	PAC SYSTEM SCREW FEEDER TRAIN A VFD FAULT / NOT READY	DI	120VAC	PAC-PLC	PAC-PLC	N-FAULT	FAULT	1I-601
YA-133-OL	PAC SYSTEM SCREW FEEDER TRAIN A THERMAL OVERLOAD	DI	120VAC	PAC-PLC	PAC-PLC	N-OVERLOAD	OVERLOAD	1I-601
PA-138-H	PAC SYSTEM SCREW FEEDER TRAIN A ANTI-BLOCKAGE SWITCH	DI	120VAC	PAC-PLC	PAC-PLC	N-HIGH PRESSURE	HIGH PRESSURE	1I-601
SE-134-ROT	PAC SYSTEM SCREW FEEDER TRAIN B ROTATION SENSOR	DI	120VAC	PAC-PLC	PAC-PLC	N-FAULT	FAULT	1I-601
YS-134-RC	PAC SYSTEM SCREW FEEDER TRAIN B VFD RUN COMMAND	DO	120VAC	PAC-PLC	PAC-PLC	STOPPED	RUN	1I-601
SC-134	PAC SYSTEM SCREW FEEDER TRAIN B VFD SPEED/CURRENT FEEDBACK	AO	4-20mA	PAC-PLC	PAC-PLC	N/A	N/A	1I-601
SI-134	PAC SYSTEM SCREW FEEDER TRAIN B VFD SPEED REFERENCE	AI	4-20mA	PAC-PLC	PAC-PLC	N/A	N/A	1I-601
YA-134-FLT	PAC SYSTEM SCREW FEEDER TRAIN B VFD FAULT / NOT READY	DI	120VAC	PAC-PLC	PAC-PLC	N-FAULT	FAULT	1I-601
YA-134-OL	PAC SYSTEM SCREW FEEDER TRAIN B THERMAL OVERLOAD	DI	120VAC	PAC-PLC	PAC-PLC	N-OVERLOAD	OVERLOAD	1I-601
PA-140-H	PAC SYSTEM SCREW FEEDER TRAIN B ANTI-BLOCKAGE SWITCH	DI	120VAC	PAC-PLC	PAC-PLC	N-HIGH PRESSURE	HIGH PRESSURE	1I-601
YS-135-RC	PAC SYSTEM MOISTURE INJECTOR START/RUN COMMAND	DO	120VAC	PAC-PLC	PAC-PLC	STOPPED	RUN	1I-601
YA-135-FLT	PAC SYSTEM MOISTURE INJECTOR THERMAL OVERLOAD	DI	120VAC	PAC-PLC	PAC-PLC	N-OVERLOAD	OVERLOAD	1I-601
PA-141-H	PAC SYSTEM MOISTURE INJECTOR ANTI-BLOCKAGE SWITCH	DI	120VAC	PAC-PLC	PAC-PLC	N-HIGH PRESSURE	HIGH PRESSURE	1I-601
WI-143-LBS	PAC SILO WEIGHT INDICATOR	AI	4-20mA	PAC-PLC	PAC-PLC	N/A	N/A	1I-601
HS-145-E-STOP	PAC SYSTEM EMERGENCY STOP	DO	120VAC	PAC-PLC	PAC-PLC	N-STOP	STOP	1I-601
YL-146-R/A/G	PAC SYSTEM STACK LIGHT (RED/AMBER/GREEN)	DO	120VAC	PAC-PLC	PAC-PLC	N/A	N/A	1I-601
LA-147-HORN	PAC SYSTEM HORN	DO	120VAC	PAC-PLC	PAC-PLC	OFF	ON	1I-601
HS-148-TIMER	PAC SILO VENT FILTER RUN TIMER	DI	120VAC	PAC-PLC	PAC-PLC	N/A	N/A	1I-601
LA-149A-H	PAC SYSTEM TRUCK FILL PANEL INDICATING LIGHT 1	DI	120VAC	PAC-PLC	PAC-PLC	N-HIGH	HIGH LEVEL	1I-601
LA-149B-L	PAC SYSTEM TRUCK FILL PANEL INDICATING LIGHT 2	DI	120VAC	PAC-PLC	PAC-PLC	N-LOW	LOW LEVEL	1I-601
LA-149C-LL	PAC SYSTEM TRUCK FILL PANEL INDICATING LIGHT 3	DI	120VAC	PAC-PLC	PAC-PLC	N-LOWLOW	LOWLOW LEVEL	1I-601

NOTE - PLEASE COORDINATE WITH VENDOR PACKAGES FOR COMPLETE I/O INFORMATION. REFER TO VENDOR INFORMATION FOR SHEETS NOT IDENTIFIED AS Ixxx.

SECTION 40 68 00 – PROCESS CONTROL SOFTWARE

PART 1 - GENERAL

1.01 SUMMARY:

A. Furnish a complete control system software package including Run Time and Development for the PAC Facility. Provide all software packages latest versions and required license for the control network. The control network shall consist of the following as minimum:
   1. Provide the enterprise software package for the Control System hardware as specified in Section 40 67 00. Including:
      a. Engineering software for managing databases and programing the PLCs.
      b. HMI graphic software.
      c. Operator Interface Terminal (OIT) programing software.
      d. Operator Interface Terminal (OIT) graphic software.
      e. The data archival, analysis, and trending software.
      f. Report generation software.
   2. The development and report generation software packages shall be provided and installed on the server.
   3. All software packages shall have the latest service packs installed.
      a. Operating system service packs shall be the latest that is compatible with the current shipping version of the control system software.

1.02 RELATED REQUIREMENTS:

A. SECTION 01 33 00 – Submittals.
B. SECTION 01 40 00 – Contractor QA/QC.
C. SECTION 01 42 00 – Definitions and Standards.
D. SECTION 01 75 00 – Manufacturer's Field Services.
E. SECTION 01 78 36 – Warranties.
F. SECTION 40 61 96 – Process Control Software Programming and Reports.
G. SECTION 40 66 00 – Process Control Networks.
H. SECTION 40 67 00 – Process Control Panels and Hardware.

1.03 REFERENCE STANDARDS:

A. As specified in SECTION 01 42 00.
B. Applicable Codes and Standards: Furnish software which conforms in all respects to applicable industry standards and sound engineering practice.
C. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.
D. International Society of Automation (ISA).
   1. ISA 101.01 – Human Machine Interfaces for Process Automation Systems.

1.04 SUBMITTALS:

A. In addition to the requirements of SECTION 01 33 00, submittals shall include the following:
   1. Product Data:
      a. Software package sales brochure
   2. Closeout Submittals: Final documentation shall include the following as minimum:
      a. Operation and Maintenance Manuals including the following:
         (1) Software all approved Product Data and licenses.
         (2) Software Technical Support Information.
         (3) Preliminary Software Programing
         (4) Preliminary Graphics

(5) Final Software Programing.
(6) Final Graphics
(7) Supplier Information.

3. Maintenance Material Submittals:
   a. Software:
      (1) Original CD/DVD-ROM disks and/or flash drives containing all software furnished.

1.05 QUALITY ASSURANCE:

A. As specified in SECTION 01 40 00.
B. All software furnished shall have an acceptable history of satisfactory use and reliability for a period of at least two years.
C. Newly released versions of the software will be considered if it has been adequately tested and proven in the market, meets the requirements of this Contract, and is approved by Contractor. Such software shall be noted in the proposal for review.
D. Installer Qualifications:
   1. Prior to installation and development, submit data of installer's experience and qualifications.
   2. Installers shall have experience with the provided software which shall include 3 years on projects of similar complexity.
   3. Include installers specific experience history in installing and developing with the specified software for projects of similar design.
   4. Include names and locations of two projects successfully completed using the specified software platform.
   5. Include written certification from users that systems have performed satisfactorily for not less than 18 months.

1.06 WARRANTY:

A. The warranty shall comply with the requirements of SECTION 01 78 36.

PART 2 - PRODUCTS

2.01 GENERAL:

A. SI shall provide the enterprise software package based on the control system hardware equipment Manufacturer as specified in Section 40 67 00.
B. Supplier shall provide all software and application specific firmware for all devices connected to the network to provide a control system which meets the functional requirements of this Section.
C. The control software shall be a full function process monitoring and control package. It shall be capable of simultaneously performing all of its functions in a multi-tasking environment.
D. The SI shall use the Manufacturers planning software to determine the system loading and work with the manufacturer to provide a manufacturer certified integrated package.
E. The Supplier shall furnish a complete control software package including Run Time and Development. Provide all software packages and required license for the control network. The control network shall consist of the following as minimum:
   1. All software modules and options to provide a complete integrated software package.
   2. All software packages shall have the latest service packs installed.
      a. Operating system service packs shall be the latest that is compatible with the current shipping version of the control system software.

F. The control software shall provide at least the following capabilities as an integrated function:
   1. Input/output functions.
   2. Modulating controls.
   3. Digital controls.
   4. Data processing and communications.
   5. Alarm functions.
   6. Sequence of events.
   7. Log functions.
   8. Operator display functions.
   9. Printing functions.
   10. Operator console functions.
   11. Programming functions.
   12. Historical data storage.
   13. Historical and real-time trending functions.
   14. Support thin client remote desktop services.
   15. Operator Interface graphics
   16. Graphics trends and displays
   17. Default system and equipment configuration libraries

G. The control software shall provide a mechanism to generate data to files with a standard format. These data files shall be accessible to other programs such as spreadsheets and database managers and shall be used to generate reports and perform data analysis outside of the control program itself.

H. The development, design, and implementation of the control system software shall comply with ISA 101.01 – Human Machine Interfaces for Process Automation Systems.

2.02 SOFTWARE AND LICENSES:

A. As a minimum the following software and licenses shall be provided to the Owner. If additional software or licenses are required for a fully operational system, they shall be provided.

2.03 COMMUNICATIONS AND PREPROCESSING:

A. General: The communications and preprocessing portion of the control software shall perform the following functions:
   1. Communicate with the PLC's located on the plant control system network.
   2. Support mutual data exchange between each operator station and PLCs on network.
   3. Support multiple communications networks and protocols concurrently.
   4. Validate, convert, process and alarm check all data received by any of the communications interfaces according to the criteria selected for each data point.
   5. Scans shall be performed continuously on all communications channels. Scans shall be sequential for those devices on the same communications network and the different communications networks shall be scanned in parallel.
   6. Periodic scan rates at different priorities shall be definable on an individual point basis or by groups of points. The scan rates shall be definable.
   7. Unsolicited messages shall be accepted and processed when sent over any of the communication networks.
   8. Processing by exception will be allowed provided the deadband is operator assignable on a point basis. The deadband will be used to inhibit preprocessing of data which has not changed by more than the preset deadband from the previous scan. The deadband shall

be assignable in engineering units or as a percentage of the scale range. An entry of zero (0) shall be acceptable for the deadband.

9. If the preprocessing functions have not been completed for certain data before new data for the same points is received in the next scan, appropriate diagnostic messages shall be directed to output devices, operator screen, printer, audible alarm, and related items, selected during system configuration.
10. Communications throughput shall be limited solely by the communications networks and not by the control software/hardware provided in this Section.
11. Provide the means to control the plant equipment or to initiate start and stop sequences from any operator station. From the operator station the operator shall have complete control of the PLC's.
12. Update displays for all points at least once every 50 milliseconds. The system shall update its own data base simultaneously. Screen call-up time for any graphic shall not exceed 3 seconds for static and dynamic data.

B. PLC Communications:
   1. The control software shall include the communications interface from the application server to the PLC network.
   2. Multiple scans per PLC at different priority scan rates shall be supported.
   3. The software shall perform any and all translations of PLC communication messages that may be required to transfer/receive data between the real-time database and the communications protocol.
   4. The communications interface shall provide all necessary error-checking and retransmission capabilities to ensure no data transmission errors.

C. Data Preprocessing:
   1. Analog Inputs:
      a. The system shall perform calculations required in the handling of analog input data including but not limited to averaging, time integrations, ranging, summations on flow measurements, and square root extractions.
      b. All analog input points shall be checked against high and/or low process limits. An analog input outside these limits shall be considered in alarm.
      c. All analog input points shall have re-alarm capabilities. Once a point is in alarm, it will re-alarm if its value continues to increase or decrease beyond the re-alarm limit assigned to that point. Re-alarm limits shall be specified in percent of input range.
      d. All analog input points shall have the capability of being assigned high and low alarm dead bands. Alarm dead bands represent the value that an input point must decrease or increase above or below an alarm set point before it activates a high or a low alarm.
      e. It shall be possible to automatically inhibit the alarming of any analog input or composed point (either analog or digital) by the state of one or more contact closure input, digital logic output, or the values of analog variables in order to eliminate nuisance alarms (e.g. low temperatures alarms disabled during start-up). The inhibiting contact closure or analog value could be different for each analog or composed point if required. When inhibiting, no alarm indication will be given to the operator and it will not be shown on alarm groups. Upon restoration of alarm functions, the point will be scanned for alarming and, if in alarm, the normal operator indication shall occur.
      f. All inhibited alarms shall be automatically logged. A summary of inhibited alarms shall be provided.

g. Provisions shall be made to avoid erroneous alarms on rate of change alarms when scanning of a point first resumes.
h. A method of differentiating between high or low alarms and "BAD" (alarms outside reasonable limits for a point) alarms should be used so that types of alarms are easily identifiable.

2. Analog Composed Points:
a. Analog composed points are defined as points resulting from calculations involving two or more analog points. The results of these calculations shall be assigned point numbers and shall be capable of being alarmed, displayed, trended, or logged.
b. Each subsystem shall have the capacity to process analog composed points. This number is in addition to any composed points per subsystem required by the system for logs. It is also in addition to any integrations, averages, weighted averages, and necessary calculations of input points.
c. Analog composed point capabilities shall be the same as specified for analog inputs.

2.04 ALARM FUNCTIONS:

A. General:
1. The system shall compare all analog input points, composed points, etc., against high and/or low alarm limits. If an input is determined to be beyond either of these limits or if a contact input designated as an alarm is determined to be in alarm, the system shall record a time-tagged alarm message to the alarm database. Simultaneously, a similar alarm message will be displayed on the operator workstation screen.
2. Once an analog point is in alarm, it shall re-alarm if its values continue to increase or decrease beyond the re-alarm limit.
3. Common alarms that are silenced or acknowledged shall be re-alarmed if another point exceeds its related alarm threshold.
4. All alarms shall have an assignable time delay to prevent an alarm message from being printed or displayed until the alarm has been present for the duration of the time delay.

B. Alarm Priorities/Levels:
1. The system shall have the capabilities to assign different priorities to points in alarm. There shall be at least four levels of alarm priorities for combinations of display, print out, or audible.
2. All points shall have the capability of pre-assignment to one of four levels for the operator screen display color to identify the alarm criticality.

C. Alarm sequence shall be as follows:
1. Alarm Occurs (Priority 1): Event recorded to alarm log and the operator screen displays alarm with a similar message in flashing red.
2. Alarm Acknowledgement (Priority 1): Operator onscreen alarm display remains red but stops flashing and alarm acknowledgement recorded to alarm log.
3. Return to Normal (Priority 1): Alarm display changes to light red. Alarm display clears when the point has been acknowledged. A return to normal is recorded in the alarm log.
4. Re-alarms: Re-alarms are treated like new alarms.
5. Alarm Priorities (1 through 4): Additional priority alarm assignments shall be treated in similar fashion but with alternate color assignments. Color assignments for priority levels shall be as defined below:
a. Priority 1: Red / Light Red.
b. Priority 2: Orange / Light Orange.
c. Priority 3: Magenta / Light Magenta.
d. Priority 4 (or Warning): Yellow / Light Yellow.

6. Additional alarm management and classifications: Alarms shall be capable of being suppressed, inhibited, and shelved. In these cases, color assignments shall uniquely identify the alarm status and current alarm classification.
7. Coordinate alarm priorities with the City.

D. One common alarm acknowledgement scheme shall be used for all alarms on the operator screens so that only one action is required by the operator to acknowledge.

2.05 EVENT NOTIFICATION:

A. The control software shall provide a fully integrated event notification package for annunciation of alarm events to personnel.
B. The following methods shall be available for communication of alarms:
   1. Local visual annunciation.
   2. Alarms shall send WIN911 SMS to operators through SCADA. Coordinate with the Owner.

2.06 OPERATOR CONTROLS

A. Supplier shall design and program all equipment using the control system manufacturer's standard library and programing blocks.
B. Each piece of equipment shall be programed with manual mode and automatic mode of operation.
   1. Manual mode the operator shall be able to start and stop the equipment as desired to open, run, test and maintain the equipment.
   2. Automatic mode the equipment shall operate as designed, intended and protected by the Supplier.
C. Equipment override stops, alarms or fault conditions shall stop the equipment and reject the equipment to manual mode so that auto logic cannot restart the equipment without operator action.
D. Coordinate all programing and graphics and displays with the Contractor and SI.

2.07 OPERATOR DISPLAY FUNCTIONS:

A. General:
   1. All standard displays shall be accessible from any operator workstation on the network. Displays shall be in high resolution color graphics.
   2. The system shall have full flexibility in specifying or changing tags, tag descriptions, ranges, scale factors, or grouping the various displays.
   3. All graphic displays should be built interactively using the supplied control system software CAD-type development program with the maximum flexibility for ease of graphics building or revision.
   4. Displays shall allow windowing for additional graphics and faceplates.
   5. The operator shall be able to use a variety of input devices to interact with the control software including keyboard, mouse, touchscreen, etc.
B. Trend Displays:
   1. The system shall have the capability to trend single variables or groups of variables simultaneously on the operator screens.
   2. The system shall allow the operator to define a minimum of 50 group trend displays.
   3. Any analog or composed point may be assigned by the operator to the trend display.
   4. Trend display for each point shall include the point description, time base, and ordinate magnitude.
   5. The trend time base shall be assignable.

6. Trending of historical information shall be available. The operator shall be able to scroll backward or forward through data.

C. Custom Graphic Displays:
1. The system shall have capabilities to easily design and display custom displays. These displays may take the form of 3D modeled graphics, plant schematics, bar graphs, and tabular data.
2. Customized displays shall be capable of showing animated graphics based on the state of the system.
3. The custom displays shall be fully interactive displays providing full process monitoring and manipulation. This interaction shall allow for the changing of set point, output, mode, ratio, bias, and function for modulating parameters. The interaction shall also allow for issuance of start/stop and open/close commands for loops.
4. The system shall have a standard group of symbols from which shapes can be made and stored in a shape library. Manufacturer standard shapes shall also be provided in the library.
5. Pixel manipulation of shapes and creation of symbols and graphics for library storage shall be available.

D. Alarm Displays:
1. Alarm Summary Display:
   a. The alarm summary display shall differentiate between the priority levels of alarm.
   b. The highest priority alarm summary shall list all primary alarms as well as points exceeding re-alarm limits. These alarms shall be listed in the sequence they were detected with the newest alarm at the top of the page.
   c. The other alarm summaries shall be displayed below the primary alarms. These alarms shall also be listed in order of detection.
   d. A point in alarm shall flash on either alarm summary display until acknowledged from the keyboard or pointing device.
   e. Messages for alarms, displayed on the screens, shall include the following information:
      (1) Point tag (ID).
      (2) Point description.
      (3) Value or status.
      (4) Engineering units (if applicable).
      (5) Limit exceeded (if applicable).
   f. At least 10 full pages of alarms should be available for historical operator information, and the operator shall be able to shift pages for alarm review.
2. Alarm Group Display:
   a. Alarm groups shall be able to be displayed on any operator workstation. Each alarm group shall represent those alarm points associated with a specific piece of equipment, operating unit, or portion of the plant.
   b. The point ID of a point in alarm shall flash on the alarm group display, until it is acknowledged from the keyboard or pointing device. The size of each alarm group shall be selectable.
   c. Any alarm group shall be capable of being disabled in its entirety or individual alarms shall be capable of being disabled selectively.
3. Alarm Diagnostics: The alarm diagnostic function shall be available to the Operator for programming specific recommended actions to the acting operator when certain alarms occur. The recommendations shall appear on the operator workstation screen in response to certain alarm conditions as an aid in operator response.

E. Point Summary Displays:
   1. It shall be possible for the operator to display summaries listed below.
   2. Display of a point summary shall include at least the following:
      a. Time.
      b. Summary heading.
      c. Point ID and description for each point in the summary.
      d. Pertinent data for each point in the summary, such as value, alarm status, alarm limits, etc.
      e. Point summaries available for operator print or display shall include at least the following:
         (1) Analog input points.
         (2) Composed points.
         (3) Contact input points.
         (4) Alarm summary.
         (5) Inputs deleted from scan.
         (6) Inserted value summary.
         (7) Bad inputs summary.
         (8) High/low reasonable limit summary.
         (9) Sequence of events logs.
   3. It shall be possible for the operator to cancel a running summary at any time.
   4. Summaries shall be displayed on any of the operator screens.

2.08 PRINTING FUNCTIONS:

A. The following defines the minimum printing functions and printing formats that shall be available to print to PDF.
B. Single Point Print:
   1. Printout of a single input point shall include at least the following:
      a. Time.
      b. Point tag (ID).
      c. Point description.
      d. Value or status.
      e. Engineering units (if applicable).
   2. It shall be possible for the operator to trend a single point. Trend interval shall be adjustable by operator.
C. Alarm Printout:
   1. The operator shall be able to print an alarm list at any time. The operator shall be able to define the number of alarm points to print.
D. Operator Screen Printout: Any display on any of the operator screens for a unit shall be able to be printed out as required to provide a hard-copy record.
E. Trend Printout:
   1. It shall be possible to print trend charts as displayed on the operator workstation.

2.09 PROGRAMMING FUNCTIONS:

A. The system shall permit the plant personnel to perform programming functions listed below. It shall be possible to perform these functions with the system on-line. All programming functions shall be under password protection.
B. All operations required to implement these changes shall be accomplished in a conversational mode via the operator screens and keyboards.

C. Programming functions shall include at least the following:
   1. Add and define new input points up to the system capacity.
   2. Modify point definition.
   3. Delete input points.
   4. Add or delete points for any group log, except for those group logs reserved for operator definition.
   5. Add or delete points to any periodic log. Change headings of period logs.
   6. Construct new graphic displays or modify existing ones.
   7. Prepare special summaries.
   8. Have the capability to add new logic programs or modify existing system logic programs with the system on-line.
   9. Modify or add performance calculations as required.
   10. Modify or add reports as required.

D. Software Maintenance:
   1. All programs required to enable the programmer to perform software maintenance functions shall be provided.
   2. These shall include program routines to permit dumping of memory, loading of memory, memory print, and related operations.

E. The control software shall include an integral interface supporting access to all real-time database entries.
   1. All database entries shall be accessible for reading, modifying and updating. Calculated results shall be capable of being stored directly onto the database.
   2. The control software shall process all data modified or stored in the database by the user programs in the same manner as all other database entries.

F. The control software shall include an integral interface allowing direct real-time access to all database items by Microsoft EXCEL and the specified historian and reporting applications.

2.10 HISTORICAL DATA STORAGE:

A. Supplier shall furnish a fully operational historical package.

B. The system shall store information taken at pre-defined intervals for at least 1,000 of any operator selected variables.

C. Access to all historical data storage functions shall be through a user-friendly, interactive menu driven type client interface.

D. All data in the real-time database shall be accessible for historical data storage.

E. All historic data required for display and report generation shall be saved on-line for a period specified by operator.

F. The amount of data stored on-line shall be limited only by the amount of available disk space.

G. Any point may be added or deleted from historical data storing at any time, on-line or off-line, without disrupting the historical data storage function.

H. Sampling of historical data storage points shall be enabled or disabled without requiring addition or deletion of these points and without disrupting the historical data storage function.

I. Provide the password protected capability to edit any data stored by the historical data storage function on-line.

J. Provide an on-line library-type interface for tracking points assigned to historical data storage.

K. The system shall include an alarm/operator action log. The log shall consist of any assigned alarms and operator actions.

L. All data shall be automatically stored and retrieved from hard disk drives in the operator stations.

M. No data shall be lost during a power interruption and no special manual boot-up procedure shall be required by the operator or technician.
N. The system shall provide an adjustable operator alarm whenever the drive capacity exceeds 80% of maximum capacity.
O. All data files shall be manually or automatically (operator selectable) archived. Archived data files shall be retrievable and the system shall have an integrated function capable of displaying retrieved archived data.
P. Provide an on-line library-type interface for tracking archival media.

2.11 DATA QUALITY:

A. Every database entry, including but not limited to scanned data from the PLC, both discrete and analog, calculated data and data received over networks, shall include indicators for data quality. The data quality indicator shall be updated every time communications with the associated device are attempted or successfully complete. The data quality indicators shall include, but not be limited to:
   1. Old/Bad Data - The point was not able to be scanned when attempted.
   2. Off Scan - The data for this point is not being updated. This indicator may be set as a result of operator request. Only an operator request can place this point back on scan.
   3. Operator Inserted Valve - this indicator is set by the greater on reset when the data is updated by scanned data.
B. A calculated point will have the old/bad data quality if any of its inputs have the old/bad or off scan quality and are not manually entered.
C. Operator entered values are considered good data.
D. Operator entered and off scan, indicators may be set and reset on calculated points by operator action and are independent of the indicators on the calculations input points.

2.12 SECURITY:

A. The control software shall provide a fully integrated password protection scheme by restricting access to system features, functions, and database points. The password protection scheme shall consist of multiple levels of access, one of which shall be full access.
B. The ability to assign and modify the access levels shall be restricted to the full access level.
C. The system shall allow assignment of multiple passwords to each access level.
D. The assignment of functions to the various access levels shall be user configurable and restricted to the full access level.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Sever Based Control Software:
   1. Install all the software and configure system for proper operation.
   2. Configure system for automatic failover as specified.
   3. Provide "staging," checkout, training, and start-up as specified and indicated.
B. Client Software:
   1. Install all the software and configure system for proper operation.
   2. Configure client software for automatic failover as specified.
   3. Configure system to automatically logoff workstations installed after 10 minutes of inactivity. Time period shall be adjustable by the Owner.
   4. Provide "staging," checkout, training, and start-up as specified and indicated.

C. Utility and Supplemental Software:
   1. Install all the software and configure system for proper operation.

3.02 CUSTOMIZED PROGRAMMING AND SCREEN DEVELOPMENT:

A. Refer to Section 40 61 96 – Process Control System Programming and Reports for customized programming and screen development requirements.

3.03 TRAINING:

A. Refer to Section 40 61 96 – Process Control System Programming and Reports for training requirements.

END OF SECTION 40 68 00

SECTION 40 70 00 – INSTRUMENTATION FOR PROCESS SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes the instrumentation requirements for measuring and controlling equipment.

1.02 REFERENCE STANDARDS:

A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.
B. ASME International:
   1. ASME B16.5 – Pipe Flanges and Flanged Fittings.
C. International Society of Automation (ISA).
   1. ISA S20 – Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves.
D. National Electrical Manufacturers Association (NEMA).
E. Underwriter's Laboratories (UL).
F. Federal Communication Commission (FCC) – Part 15

1.03 SUBMITTALS:

A. Submit in accordance with Section 01 33 00.
B. Product Data:
   1. Specification Datasheets, Manufacturer Cut sheets and installation requirements.
C. Shop drawings
   1. Electrical and mechanical connection diagrams.
   2. Outline drawings.
D. Test and Evaluation Reports:
   1. Factory test and calibration reports.
   2. Field test and calibration reports.
E. Closeout Submittals: Final documentation shall include the following as minimum:
   1. Operation and Maintenance Manuals including the following:
      a. Operation and maintenance manuals for all instruments furnished.
      b. Copies of all approved Product Data.
      c. Copies of all approved Test and Calibration Reports.
      d. Spare parts and supply list.
      e. Warranty Information.
      f. Subcontractor Information.
      g. Training Materials. Includes final edited training videos.

1.04 SITE CONDITIONS:

A. All Equipment provided as part of this system shall be rated for the temperature, seismic and elevations as specified in the Site Conditions in Section 26 00 00.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

A. Instrument manufacturer shall be selected based on the Control System Manufacturer where possible as specified in Section 40 67 00.

1. For Schneider Electric systems - Modicon is selected as the control system where possible Endress+Hauser shall be the instrumentation.

B. Analyzer Indicating Transmitter (AIT) (Process Analyzers)

C. Total Suspended Solids (TSS) Sensor
1. YSI (Xylem) ViSolid 700 IQ
2. Endress+Hauser Turbimax CUS51D
3. Engineer approved equal

D. Chlorine Analyzers:
1. Endress+ Hauser Memosens CCS53E
2. Halogen MP-5A
3. Engineer approved equal

E. Instrument Tubing (Rigid & Flexible)
1. Swagelok
2. Parker

F. Limit Switches (LS*)
1. Allen-Bradley, Rockwell Automation, Inc.
2. Square D, Schneider Electric.

G. Temperature Switches (TS*)
1. Emerson
2. Endress+Hauser
3. ABB
4. WIKA

H. Pressure Switches (PS*)
1. Allen-Bradley, Rockwell Automation, Inc.
2. Ashcroft, Inc.
3. Dwyer Instruments, Inc.
4. SOR, Inc.
5. United Electric controls

I. Temperature Indicating Transmitters (TIT):
1. Emerson
2. Endress+Hauser
3. Honeywell
4. Yokogawa
5. ABB

J. Vibration Indicating Transmitter (VIT or VSH)
1. Baker Hughes
2. Emerson
3. Metrix
4. Rockwell Automation
5. SKF

2.02 GENERAL:

A. Provide instruments as indicated on the instrument schedule.

B. Instruments other than analyzers should be Bluetooth capable with free phone app whenever possible. Analyzers may be Bluetooth enabled but not required.

C. Tag all instruments with Contractors Tag number before shipping to site with stainless steel Device Tag as specified.

D. Transmitters shall have an output signal of 4 to 20 mA dc into a minimum load range of 0-600 ohms at 24Vdc, capable of HART communication protocol in accordance with the control system manufacturer to provide instrument calibration and diagnostic information.
E. All analog indicating and recording receivers shall have evenly graduated scales.
F. Provide all mounting brackets, pipe stands and accessories required to install all field mounted instruments. All mounting brackets and hardware for instruments installed in exterior locations or within process areas shall be stainless steel.
G. Furnish and install all accessories required for complete and working systems as specified and indicated.
H. Provide sun shades for all exterior mounted transmitters.
I. All flanged instruments shall comply with ASME B16.5.
J. Instruments located in hazardous locations as indicated on the instrument schedule shall be rated for use in Class I, Division 1 hazardous environments. Provide intrinsically safe barrier in source control panel as required. Barriers shall be as specified in Section 40 67 00.
K. Where 4-wire instruments require external power, the instrument shall be powered from 120 VAC UPS power from control panels as specified in the Section 40 67 00.
L. Provide LCD displays for all transmitters.
M. Provide transient protection terminal blocks for all outdoor located equipment when available.

2.03 DEVICE TAGGING:

A. Device tags shall be stainless steel minimum 0.040-inch thickness with correct Contractor tag number and service description stamped, engraved, or laser etched clearly into the metal.
B. Device tags shall be permanently attached with minimum 18-gage stainless-steel wire to the stem or case of each Instrument, use of string or tape is unacceptable.
C. The Contractor's tag number and service description is listed in the Instrument Schedule.
D. Provide device tag for each device furnished by this Contract prior to shipment.
E. Provide and attach a device tag to all devices received that do not have a device tag, whether furnished by this Contract or by others, and as directed by the Contractor.

2.04 ANALYZER INDICATING TRANSMITTERS

A. Provide digital multiparameter transmitter:
    1. Rated for Non-Hazardous Areas.
    2. Provide IP66 rated enclosures.
    3. Ethernet communication port, capable of multiple communication protocols.
    4. Capable of 4 digital plug and play sensors.
    5. Provide with 2 relay outputs and 2 analog outputs (Spare).
    6. Require 120 VAC external power.
    7. NPT Conduit entries.
    8. The transmitter unit shall have a built in data logger function.
    9. Include analyzer heartbeat and verification monitoring.
B. Provide pre-calibrated sensors:
    1. The probe shall have an integral sensor cable with a continuous length of cable for connection to the transmitter at location indicated. The cable shall be terminated with a quick-disconnect plug.
    2. The sensor shall include built-in digital electronics.
    3. The built-in electronics of the sensor shall be completely encapsulated for protection from moisture and humidity.
    4. Include probe mounting hardware, details provided later.
    5. TSS Probe

a. Provide a factory calibrated sensor for measuring the intensity of scattered light and backscatter in low concentration (mixed liquor, return activated sludge) and high concentration (primary sludge, thickened sludge) applications.
b. The sensor shall have capability for automatically selecting the optimal resolution for each measured value with repeatability according to DIN ISO 5725 or DIN 1319 <0.015% or > 0.0006 FNU.
c. The sensor shall include self-diagnostics to detect contamination of sapphire optical window and failure of cleaning system, and equipped with a non-mechanical integrated ultrasonic cleaning system.
d. The sensor shall have a digital output signal using a detachable sensor cable allowing for easy replacement or repair.
e. The sensor shall be housed in an IP-68 rated, V4A stainless steel enclosure, designed to be nonincendive and nonarcing, provided with integral lightning protection, and capable of 145 psi depth submergence.
f. Temperature Conditions:
   (1) Operating: 32 to 140 °F (0 to 60 °C)
   (2) Storage: 23 to 149 °F (-5 to 65 °C)
g. Cable: Manufacturer-provided cable included.
h. TSS Range Concentration: 0 to 400 mg/L; 0 to 4000 mg/L; 0 to 25,000 mg/L; 0 to 40,000 mg/L Saturation: 0.0003 to 100% (practical limit: 4%) TSS
i. Resolution Auto-Ranging: 0.1 mg/L to 1 mg/L, 0.001%, 0.01% or 0.1%
j. Certifications UL 61010-1, CAN/CSA C22.2 # 61010.1
k. Accessories:
   (1) Calibration Kit: Required.

6. Free Chlorine Probe:
   a. Provide a factory-calibrated amperometric sensor for continuous measurement of free chlorine in potable water, wastewater effluent, reuse water, and industrial water treatment applications.
   b. The sensor shall utilize bare-electrode amperometric technology and shall provide direct free chlorine measurement without the use of reagents, membranes, buffers, or sample conditioning systems.
   c. The sensor shall incorporate integrated pH, temperature, and conductivity measurement for automatic compensation and improved measurement accuracy over varying process conditions.
   d. The sensor shall include self-diagnostic capabilities to detect electrode fouling, sensor failure, abnormal process conditions, and loss of signal, and shall provide diagnostic status through the analyzer output.
   e. The sensor shall provide a digital output signal and be furnished with a detachable sensor cable to facilitate maintenance, replacement, and calibration.
   f. The sensor shall be housed in a corrosion-resistant enclosure suitable for continuous immersion and wet-tap installations and shall be designed for municipal and industrial water treatment environments.
   g. Temperature Conditions:
      (1) Operating: 32 to 122 °F (0 to 50 °C)
      (2) Storage: 14 to 140 °F (-10 to 60 °C)
   h. Cable: Manufacturer-provided cable included.
   i. Free Chlorine Measurement Range: 0.00 to 20.00 mg/L (ppm) as Cl_2.
   j. Resolution: 0.01 mg/L (ppm).
   k. Accuracy: ±0.05 mg/L or ±5 percent of reading, whichever is greater.

l. Response Time: 90 percent of final value in less than 2 minutes.
m. Integrated Measurements:
(1) pH Range: 6.50 to 8.75 pH
(2) Conductivity Range: 50 to 10,000 µS/cm
(3) Temperature Range: 32 to 122 °F (0 to 50 °C)
n. Certifications:
(1) UL 61010-1
(2) CAN/CSA C22.2 No. 61010.1
o. Accessories:
(1) Calibration Kit: Required.
(2) Immersion Mounting Assembly: As indicated on the Drawings.

2.05 FLEXIBLE INSTRUMENT TUBING:

A. Flexible instrument tubing shall be corrugated hose braided and reinforced, with permanently attached male nominal pipe thread ends.
B. Manufacturer, Product:
C. Braid: 316 or 321 stainless steel.
D. Fittings: 316 stainless steel.
E. Length: Nominally 36 inches unless otherwise specified.

2.06 LIMIT SWITCHES:

A. SPDT contacts rated 5 amps at 120Vac minimum.
B. Snap action type switch.
C. NEMA 4X or IP equivalent aluminum housing.
D. Operator type as required for the function specified or indicated.

2.07 TUBING:

A. General:
1. Tubing shall be:
a. Seamless fully annealed and suitable for bending.
b. Stainless-steel ASTM A269 or A213 min or average wall tubing.
c. Hardness not greater than Rockwell B90.
d. 1/2-inch OD with 0.049-inch wall thickness, Grade TP316.

2.08 TUBING FITTINGS:

A. All tubing fittings provided by this Contract shall be by the same manufacturer.
B. Grip type flareless tubing fittings shall be one of the following:
1. Swagelok.
C. Parker A-lok.

2.09 INSTRUMENT SHUTOFF AND BLOWDOWN VALVES:

A. General:
1. Body sizes: Same as connecting tubing or piping.
2. End connections:
a. Tubing systems: Use integral tube fittings or adapter tubing fittings. Fittings shall be as specified in this Section PART 2 - TUBING FITTINGS.
b. Piping systems: Match respective process pipe line or 316 stainless steel.
3. Type: Ball valve.
4. Body: Bronze, rated 400 psig at 150ºF.

5. Packing: Reinforced Teflon.
6. Seats: Reinforced Teflon.
7. Trim: 316 stainless-steel ball and stem.
8. End Connections: 1/2-inch FNPT.
9. Manufacturer, Product:
    a. Apollo, Series 70-100.
    b. Nibco, Series 580 and 585.

2.10 INSTRUMENT MANIFOLD VALVES:

A. General:
1. Shop or field fabrication of manifold instrument valves using individual instrument valves and tubing or piping is not acceptable.
2. Include all necessary flange bolts and flange seals.
3. Provide 2-inch pipe mounting bracket.
4. Provide metal to metal seats.
5. Include plugged test connection on each process sensing line for calibration without removing manifold instrument valve.
6. Furnish with 1/4-inch stainless-steel plugs for test connections.
7. Body: 316 stainless steel.
8. Packing: PTFE
9. Trim: Stainless steel.
10. Connections: 1/2-inch FNPT.
11. Manufacturer, Product:
    a. Anderson Greenwood & Co.
    b. Swagelok.
    c. Parker.

2.11 TEMPERATURE TRANSMITTERS:

A. Provide loop powered temperature transmitter for monitoring of air or liquid temperature.
B. NEMA 4X or IP equivalent aluminum housing with LCD display.
C. Provide 4-20mA analog signal proportional to temperature.
D. Suitable for wall or process mounting.
E. Spring loaded platinum RTD sensing element.
F. Provide compact stainless steel sensing element when used for ambient air sensing applications.
G. Provide stainless steel thermowell with a 4-inch immersion length and a 1-inch process connection when used for liquid or air sensing in a pipe.

2.12 TEMPERATURE SWITCHES:

A. Provide adjustable temperature switch as indicated and specified.
B. Nominal temperature setting shall be adjustable between 75°F and 205°F. Setpoint shall be as indicated.
C. Shall have a minimum of one SPDT relay output that shall close when the temperature drops below or rises above the set point.
D. Output contacts shall be rated a minimum of 5 Amps at 120Vac.
E. NEMA 4X or IP equivalent aluminum housing with LCD display.

PART 3 - EXECUTION

3.01 GENERAL:

A. Perform all Work necessary to install, connect, tube, wire, pipe and calibrate:
   1. In strict accordance with the manufacturer's recommendations.
   2. To make instruments and controls ready for successful operation.
   3. As specified and indicated on the instrument schedule and the Instrument Installation Details included on the Process and Instrumentation diagrams (P&IDs), and Electrical Plan Drawings.

B. Provide all material to mount on floor or wall.

C. Mount instrument plumb and level.

D. Mount instrument four feet above floor unless indicated otherwise and instrument case spaced at least 1/2-inch away from wall.

E. Provide all equipment, materials, scaffolding, rigging, and tools to complete the Work.

F. Provide all labor, including expert and common, specialized personnel, fitters, electricians, instrument technicians, and attendance of such personnel.

G. Coordinate all installation activities involving others. Identify restraints caused by others which affect performance of the Work. Resolve such restraints where possible, and notify the Engineer when additional action is required to complete the Work.

H. Electrical Plan Drawings shall be used to determine approximate location of instruments to be installed and their sensing line connections. Subcontractor shall advise the Contractor of interferences.

I. Instruments not indicated on the Electrical Plan Drawings but listed in the Instrument schedule, shall be field located by the Subcontractor with the assistance of the Contractor.

J. Install device tags for all devices without tags or as directed by the Contractor.

K. Apply lubricant to threads of screwed transmitter covers prior to installation.

3.02 TUBING AND PIPING:

A. Fabricate and erect each sensing line from the root valve to the instrument, including tubing, piping, fittings and supports for each device.

B. Tubing and piping arrangements shall be as indicated. Install offsets, fittings, unions, vents, drains, and supports to make a complete installation.

C. Install unions or flanges for each instrument or control device to allow convenient removal as follows:
   1. Install so lines may be broken for maintenance, valves removed and equipment disconnected.
   2. Install in lines erected without such unions or flanges but, in the opinion of the Contractor, cannot be properly maintained without them.
   3. Install flanges with bolt insulator kits or dielectric insulated unions for joining dissimilar piping materials, such as copper to iron or steel. Install such insulating devices in positions which receive axial loads only with no bending loads.

D. Support tubing as follows:
   1. Support individual copper tubing continuously along the entire length.
   2. Support stainless-steel tubing either continuously or from individual supports with spacing not to exceed the following distances:
      a. For 1/4-inch OD tubing, use 3 feet maximum spacing.
      b. For 3/8-inch OD tubing, use 4 feet maximum spacing.
      c. For 1/2-inch OD tubing, use 5 feet maximum spacing.
   3. Supports shall allow for thermal expansion of tubing and equipment.
   4. Provide vibration isolating materials, which in the opinion of the Contractor are required to prevent tube surface damage due to rubbing on supports.

E. Tubing and piping shall be installed either perpendicular to or parallel, to the building structure, the floor or the major equipment.
F. Tubing and piping shall be installed with a minimum clearance of 7 ft.-6 inches over passageways and walkways.
G. Verify tube fitting pull-up with the manufacturer's gap inspection gage.
H. Clean and blow out all tubing with compressed air prior to connecting to instruments.
I. Verify that the tubing systems are tight and do not leak. Repair all leaks found.
J. Install flexible instrument tubing in sensing lines where substantial relative movement occurs between the instrument and the process connection. Install where required and directed by the Contractor. Flexible tubing end connections shall be installed in the same plane and free from all torsion effects during service conditions and non-operating periods.

3.03 FREEZE PROTECTION OF INSTRUMENT TUBING AND PIPING:

A. Heat-trace shall be furnished for tubing or piping located outdoors and containing steam, water, moist air, or moist gas. Instruments and related sensing lines subject to freezing are identified on the instrument installation details or P&IDs, if there is a line subject to freezing located outdoors not requiring heat trace Subcontractor shall notify the Contractor that heat trace should be installed.
B. Sensing lines for differential pressure type instruments requiring heat tracing shall have their sensing lines routed together, side-by-side, as indicated on the Instrument Installation Details, to accommodate common heat-tracing and insulation so that the two sensing lines have the same temperature.

3.04 HEAT-TRACED TUBING BUNDLE:

A. Install heat-traced tubing bundle for all outdoor portions of all sensing lines and instrumentation containing water, steam, moist air, or moist gas.
B. Install heat-traced tubing bundle for all sensing lines and instrumentation as indicated on the Instrument Installation Details.
C. Install and support heat-traced tubing bundle in strict accordance with the manufacturers' instructions.
D. Application of the various types of heat-traced tubing bundles shall be consistent with the products specified in this Section PART 2 - HEAT TRACED TUBING BUNDLE, except as indicated on the Instrument Installation Details.
E. Install all differential pressure type instruments with both sensing lines in the same heat-traced tubing bundle to maintain similar temperature and routing between the two the two legs, except as indicated on the Instrument Installation Details.
F. Install the following on the heat-traced tubing:
    1. Instrument enclosure entry seal kits where the heat-traced tubing bundle enters an instrument enclosure.
    2. Termination seal kits at the non-powered end of the heat-traced tubing.
    3. In-line, tee, and heater cable splice kits where heat-traced tubing field connections are required. Kit entries shall be sealed with silicone or mastic material.
    4. Elbow transition kits where heat-traced tubing bundle field installation requires.
    5. Jacket patch kits for minor jacket repairs.
    6. Electrical power connection and termination kits.
G. All power wiring within one instrument enclosure shall be wired to one set of terminals for connection to a single 120Vac power source.
H. The Freeze Protection System will automatically turn power on below 40ºF ambient and off above 40ºF ambient.

3.05 VALVES IN TUBING:

A. Install Instrument Shutoff Valve or Instrument Manifold Valve for each device as indicated on the Instrument Installation Details. Type of valve shall be as indicated on the Instrument Installation Details.
B. Install Instrument Manifold Valve for the sensing lines to each differential pressure device.
C. Install blowdown valves for each remote-mounted devices as indicated on the Instrument Installation Details. Type and quantity of valves shall be as indicated on the Instrument Installation Details.

3.06 INSTRUMENT STANDS:

A. Install Instrument Stands with mounting plates, floor stands, brackets, and supports to provide rigid installation.
B. Freestanding Instrument Stands shall be suitably braced and attached to the floor or supporting structure to provide a rigid mounting structure for the instruments.
C. Provide one inch of grout under concrete floor mounted instrument stands.
D. Instrument Stands and other mountings in platform grating areas shall be attached to structural steel or rigid structures. For instrument stands on platforms, weld base plates to building steel.
E. Furnish all anchors, channels, brackets, and supports for a secure, rigid, and complete installation for the Instrument Stands and installed instruments. Do not support Instrument Stands from grating or handrails.
F. Mounting plates and miscellaneous supports shall be attached to structural steel or rigid structures.
G. Instruments shall be mounted such that they are protected from physical damage, weather, heat, and vibration.
H. Instruments shall be mounted to provide easy access for calibration, repair, disconnection, removal, and replacement.
I. Mount Instrument Blowdown Valves to the Instrument Stand with mounting plates, brackets, and clips.

3.07 INSTRUMENT ENCLOSURES:

A. Instrument Enclosures or sun shields shall be furnished for instruments located outdoors.
B. Instrument Enclosures or sun shields shall be rigidly mounted to Instrument Stands.

3.08 ANALYZERS:

A. Install probes, sample tubes, signal conditioners, analyzer cabinets, drains, purging air piping, blowers, mounting flanges and couplings.
B. Fabricate and erect all tubing and piping as indicated on the Instrument Installation Details.
C. Clean probes during initial operation, per the manufacturers' recommendations.
D. Do not install analyzer probes until the system is ready to be turned over to the Owner or permission has been given by the Contractor. If probes dry out or become damage by not following manufacturers recommendations they shall be replaced by the Contractor at no cost to the Owner.

3.09 GROUT:

A. Provide one inch of grout under concrete floor mounted supports.
B. Provide grout as indicated on the Instrument Installation Details.
C. Material shall be as specified in Division 3.

3.10 PRESSURE-SENSING INSTRUMENT ACCESSORIES:

A. Install pulsation dampeners on all line-mounted pressure-sensing instruments where:
   1. Process fluid pulsing is detected.
   2. The instrument measures a pump's discharge pressure.
   3. Install siphon tubes on all line mounted steam pressure sensing instruments where the instrument is mounted above the process connection.

3.11 TEMPORARY INSTRUMENTATION:

A. Furnish temporary gauges for pressure and temperature measurement during piping system flushes and hydrostatic testing.
B. No permanent instrumentation shall be in service at this time.

3.12 TESTING:

1. Leak Testing of Tubing Systems: Initial service leak testing shall be performed on all sensing and signal line tubing systems. This includes all tubing, piping, instrument shutoff valves, manifold valves, and blowdown valves, located after the root valve. Repair any leaks found.

3.13 DEVICE CALIBRATION:

A. General:
   1. Industry standards and manufacturers' recommendations shall be followed in the execution of this Work.
   2. Whenever possible, devices shall be calibrated prior to installation according to the calibration procedures specified below.
   3. Provide all test instruments, calibration standards, and devices required to perform calibration and testing procedures. Alternative test equipment must be approved by the Contractor.
   4. Instrument calibration shall be witnessed by the Owner, Contractor or any other person assigned by the Owner or Contractor. Provide to the Contractor daily calibration Work schedule.
   5. Coordinate the Work with others so that calibration is completed prior to equipment startup or system turnover dates or as directed by the Contractor.
   6. Calibrate in strict accordance with manufacturers' recommendations. Instruction books are available from the Contractor for instruments furnished by others.
   7. Power all transmitters from system power supplies for calibration. Allow manufacturer's recommended warm up time prior to start of calibration of device. Use of portable power supplies or batteries to power transmitters for Device Calibration is not allowed.
   8. Calibrate all instruments to the calibration ranges and set points specified on the respective instrument datasheets or as indicated on vendor drawings.
   9. If the instrument is of the "smart" family, verify the internal configuration data is as specified on the respective instrument datasheet.
   10. Immediately after Device Calibration, attach a calibration label or self-adhesive calibration sticker to the device with the name of the person performing the calibration and date of calibration.
   11. When devices are removed from equipment, ensure the connection is protected from contamination. Clean devices such that reinsertion or installation of the device does not contaminate the equipment.
   12. Report defective equipment to the Contractor.

13. Assist and cooperate with Contractor at all times through the calibration of the instruments to insure that such activities do not interfere with the planned operation of the facility.

B. Pressure or differential pressure devices:
   1. All pressure devices shall be calibrated to read the pressure at the process root valve.
   2. If pressure device does not have a Q4 calibration sheet:
      a. Use certified dead weight tester, manometer or Wallace and Tiernan pneumatic calibration unit to validate all certified calibration pressure gauges used in the calibration of all other non-calibrated devices.
      b. Adjust zero and span of device to read the pressure at the process root valve.
      c. Use a vacuum or pressure hand pump and certified calibration pressure gauge to verify and record device pressure output readings at 0, 25, 50, 75, and 100% of input value.
      d. Record alarm point and failed sensor values.
      e. Record device hysteresis.
      f. Remove test equipment and verify that the instrument output reads the correct pressure.
   3. A device provided with a factory calibration sheet can be considered calibrated unless it is in a service with a static liquid leg or similar application, calibrate the device with the procedure outline above to provide appropriate static liquid correction so zero is measured at the root valve.

C. Temperature devices:
   1. Thermocouples and extension lead wire shall be checked for proper type polarity and grounding. The temperature element will be check with an ohm meter for continuity. Record the resistance
   2. RTD wiring shall be checked for proper type polarity and grounding. The temperature element will be check with an ohm meter for continuity. Record the resistance.
   3. Temperature switches shall be checked by immersion in a temperature regulated oven or bath. Record actuation point and any dead ban.

D. Level controllers and liquid level switches:
   1. Fill the float chamber with water observe the operation of the device.
   2. Lift float switches to activation point.
   3. Record the controller output over the entire range of the input, verify the correct controller response or the activation of the switch occurs at the level setpoint specified.

E. Switches, other than liquid level:
   1. All switch positioning shall account for dimensional changes that may occur when the equipment is placed in service.
   2. Apply process input and adjust switch actuation points to specified value.
   3. Record if switches make and break with an electrical continuity check.
   4. Adjust dead band if applicable.
   5. Verify repeatability of switch actuation points after adjustments are completed.

F. Other transmitters and signal converters:
   1. Apply power, input signal, and process input, as applicable.
   2. Adjust zero and span.
   3. Calibrate per manufacturer instructions for the applicable process measurement.

G. Motor operated valves:
   1. Apply power to the motor.
   2. Use the control system to stroke the valve.

3. Record valve position over the entire input signal range; confirm whether valve is direct acting or indirect acting as required by the application.
4. Record readings or output of device at 0, 25, 50, 75, and 100% of input value.
5. Record device hysteresis.
6. Adjust limit switches to actuate at values indicated. Confirm switches make or break with an electrical continuity check.
7. Apply power to the position transmitter and adjust zero and span to represent 0 to 100% open position of the control valve.

H. Magnetic flow meters:
1. Apply power and allow the manufacturer's recommended warm-up time.
2. With a HART Communicator calibrate the meter using the manufacturers recommended procedure.

I. DO, pH and ORP probes:
1. Remove probe from installation and install electrodes.
2. Place probe assembly into standard solution. Use three solutions: One near scale zero, one midrange and one near full scale. Record accuracy at each point and adjust to reach accuracy stated on the Instrument Data Sheets.
3. Install probe in place if ready for operation; if not ready for operation, remove cells and keep cells immersed in water and label container with analyzer tag number. The Subcontractor shall keep the electrodes wet during start-up and account for them until they are accepted by the Contractor.

J. Analyzers:
1. Apply power and allow the manufacturers recommended warm-up time.
2. With a HART Communicator calibrate the analyzer using the manufacturers recommended procedure.

K. Receiving devices, including recorders and indicators:
1. Apply applicable electrical or pneumatic input signals and power.
2. Adjust zero and span for reach range.
3. Record readings or output of device at 0, 25, 50, 75, and 100% of input value.

L. CO, CH_4, H_2S and other analyzers: In accordance with manufacturer's instructions. Assist service representative when requested.

3.14 INSTALLATION VERIFICATION:

A. Confirm that the instrument is mounted as indicated on the installation details and P&IDs.
B. Confirm the sensing lines are:
1. Connected to the proper pipeline, vessel or other equipment.
2. Connected to the proper instrument connections, hi side or low side.
3. Installed and adequately sloped in the appropriate direction with no pockets that would trap process material.

C. Confirm that the installation is properly supported, and there is no excessive vibration.
D. Confirm that level measuring devices are installed at the proper elevation.
E. Confirm that instrument air supplies are properly connected and adjusted to the correct pressure.
F. Confirm that signal lines are properly connected to the correct receiving device.
G. Confirm instrument is rated for electrical power run to the device and that it is correctly terminated.

3.15 LOOP TESTING:

A. General:

1. Coordinate with the Contractor and operator for the for all loop testing activities.
2. After Device Calibration and Verification of Installation has been completed for all devices in a loop, perform Loop Testing to functionally check all signals and devices within the loop display and operate correctly from the PCS. Loop Testing shall be performed on all control loops.
3. Verify operation of each instrument relative to transmitting and receiving devices in the loop.
4. Verify calibration of each instrument within the loop.
5. Verify performance of instruments that are part of electrical control schemes in order to assist the Equipment manufacturer's service representative or Contractor to functionally test the schemes.
6. Recalibrate, replace, or repair all of the loop devices as required to obtain the stated accuracy.

B. Modulating Loops:
1. Apply process input as specified in this Section PART 3 - DEVICE CALIBRATION or for smart transmitters manually control the output of the loop primary sensing device. Set the process to 50% of range and verify whether the loop is direct acting or indirect acting as required by the application.
2. Apply process values equal to 0, 25, 50, 75, and 100% of range of primary sensing device. Record readings of all receiving devices at each of these input values. Also record value of primary sensing device output signal at each point.
3. Adjust receiving device and transmitting device as required so that readout from receiving devices is within 1% of the value of the process input.
4. Verify that the direction of response is consistent with the control system output.
5. For output signal values of 0, 25, 50, 75, 100% from the control system, record the loop final element position in percent or degrees open.
6. If loop contains a signal converter device, such as an I/P converter, record for each output signal value from the faceplate control station the value of the input and output signals of the converter.
7. For control valve positioner or I/P converter recalibrate to obtain desired relationship between faceplate control station output and control valve position.
8. Make adjustments as required to the control drive linkage, for control drive or I/P converter recalibrate to obtain desired relationship between faceplate control station output and damper position.
9. For limit switches, verify that actuation point of limit switch is within 2% of the value specified. Adjust or recalibrate switch if required.
10. For modulating output signals from the control system to receiving devices:
    a. Have the SCADA operator place the output signal in manual.
    b. Apply signal values equal to 0, 25, 50, 75, and 100% of output signal range.
    c. Record readout of receiving devices for each value of input signal above.
    d. Adjust or recalibrate receiving device as required so that readout of device is within 1% of input signal value.
11. For modulating loops containing transmitters, receiving devices and final control elements, proceed as follows:
    a. Loop test transmitters and receiving devices in the loop.
    b. Apply process input as specified in this Section PART 3 - DEVICE CALIBRATION or for smart transmitters manually control the output to loop transmitters. Verify that output of controllers is in the proper direction for process input values above and below controller set point.

c. Verify null calibration of controllers by setting process input to set point and increasing controller reset adjustment. Adjust or calibrate controller as required so that controller output does not change under these conditions.
d. Verify that direction of response of loop final control elements is in the direction specified for process input values above and below controller's set point.
e. Record reading of the position of final control elements for input signal values of 0, 25, 50, 75, and 100% to these devices. Adjust or recalibrate final control device to obtain desired relationship between input signal value and final control element position.
f. If final control devices have limit switches, verify that actuation point of limit switch is within 2% of value specified. Adjust or recalibrate switch if required.

C. Discrete Loops:
1. Functionally test electrical control schemes designed for the purpose of controlling operation of equipment, including motors, pumps, motor-operated valves, solenoid-operated pneumatic valves and similar field equipment. By performing all of the functions described below. These functions shall be performed under the coordination and supervision of the Contractor.
a. Apply process input as specified in this Section PART 3 - DEVICE CALIBRATION.
b. Verify that switch actuation point is within 1% of that specified. Verification of switch actuation shall be by electrical continuity test.
c. Remove process input from instrument, when requested, and verify switch returns to "on the shelf" state.
d. Repeat a. and b. above as required for Contractor to witness the operation from the plant PCS to complete functional test of control scheme.
e. Verify that final control devices are interfaced to the control system operate as intended by the design of the control scheme. If final control device has limit switches, verify that these actuate within 2% of specified actuation value.
2. If a non-modulating type instrument is utilized to provide an input to the control system, perform a loop test as follows:
a. Apply process input as specified in this Section PART 3 - DEVICE CALIBRATION.
b. Verify that actuation point of switch is within 1% of that specified and that the input is received at the terminals of the control system. Verification shall be by electrical continuity test.

3.16 TUNING:

A. After Loop Testing or during start-up of the process system or equipment, tuning adjustments are required to obtain safe and smooth control action within the range of design limits of the equipment. SI shall tune all loop, including PID controllers and constants wired to the control system.
B. Verify that the instrumentation is operating within design limits and at design point.
C. Vary the process load, and verify that the control system or instrument response is within design limits over the entire range.
D. Stroke remotely operated valves and dampers as required for loop tuning.
E. Ramp variable frequency drives through their operating range with setpoint changes as required for loop tuning.

F. Adjust controllers for optimum response. Adjust proportional band, reset, rate and set point as required to obtain safe and smooth control action within the range of design limits of the equipment.
G. Provide expert attendance and labor to manufacturer's representative for adjustments to the control system.
H. Record and submit all tuning constants to the Contractor and the Owner on the loop checkout sheets.

3.17 TESTING:

A. Cooperate and coordinate with other contracts as required when the testing of all devices, as outlined below, involves such other contracts. This shall include, but not be limited to, coordinating the following:
   1. Scheduling as directed by the Contractor.
   2. Manpower requirements, including expert and common labor, specialized personnel and supervision.
   3. All equipment and testing devices required.

END OF SECTION 40 70 00

ATTACHMENT

INSTRUMENT LIST

TAG NUMBER	DESCRIPTION	DEVICE TYPE	CONTROL POINT	SET POINT	CAL. RANGE MIN	CAL. RANGE MAX	SET POINT / CAL. RANGE UNIT	FURNISHED BY	INSTALL DETAIL	WIRED BY	ELECTRICAL DWG / SPEC.	PIDDwg	NOTES
PS-138-H	PAC SYSTEM SCREW FEEDER TRAIN A ANTI-BLOCKAGE SWITCH	PRESSURE SWITCH	PAC-PLC	BY VENDOR	BY VENDOR	BY VENDOR	PSI	VENDOR	VENDOR	CONTRACTOR	40 70 00	1I-601	
PS-140-H	PAC SYSTEM SCREW FEEDER TRAIN B ANTI-BLOCKAGE SWITCH	PRESSURE SWITCH	PAC-PLC	BY VENDOR	BY VENDOR	BY VENDOR	PSI	VENDOR	VENDOR	CONTRACTOR	40 70 00	1I-601	
PS-141-H	PAC SYSTEM MOISTURE INJECTOR ANTI-BLOCKAGE SWITCH	PRESSURE SWITCH	PAC-PLC	BY VENDOR	BY VENDOR	BY VENDOR	PSI	VENDOR	VENDOR	CONTRACTOR	40 70 00	1I-601	
WE-142A	PAC SILO LOAD CELL A	SCALE	PAC-PLC	BY VENDOR	BY VENDOR	BY VENDOR	LBS	VENDOR	VENDOR	CONTRACTOR	40 70 00	1I-601	
WE-142B	PAC SILO LOAD CELL B	SCALE	PAC-PLC	BY VENDOR	BY VENDOR	BY VENDOR	LBS	VENDOR	VENDOR	CONTRACTOR	40 70 00	1I-601	
WE-142C	PAC SILO LOAD CELL C	SCALE	PAC-PLC	BY VENDOR	BY VENDOR	BY VENDOR	LBS	VENDOR	VENDOR	CONTRACTOR	40 70 00	1I-601	
WE-142D	PAC SILO LOAD CELL D	SCALE	PAC-PLC	BY VENDOR	BY VENDOR	BY VENDOR	LBS	VENDOR	VENDOR	CONTRACTOR	40 70 00	1I-601	
WQ/WIT-143-LBS	PAC SILO LOAD CELL SUMMING CARD AND TRANSMITTER	WEIGHT TRANSMITTER	PAC-PLC	BY VENDOR	BY VENDOR	BY VENDOR	LBS	VENDOR	VENDOR	CONTRACTOR	40 70 00	1I-601	
HS-148-TIMER	PAC SILO DUST FILTER/TIMER BUTTON	PUSH BUTTON	PAC-PLC	ON / OFF	N/A	N/A	N/A	VENDOR	VENDOR	CONTRACTOR	40 70 00	1I-601	
LS-149A-H	PAC SILO FILL PANEL LEVEL INDICATOR A	SWITCH - HIGH	PAC-PLC	BY VENDOR	BY VENDOR	BY VENDOR	FT	VENDOR	VENDOR	CONTRACTOR	40 70 00	1I-601	
LS-149B-L	PAC SILO FILL PANEL LEVEL INDICATOR B	SWITCH - LOW	PAC-PLC	BY VENDOR	BY VENDOR	BY VENDOR	FT	VENDOR	VENDOR	CONTRACTOR	40 70 00	1I-601	
LS-149C-LL	PAC SILO FILL PANEL LEVEL INDICATOR C	SWITCH - LOW LOW	PAC-PLC	BY VENDOR	BY VENDOR	BY VENDOR	FT	VENDOR	VENDOR	CONTRACTOR	40 70 00	1I-601	
HS-145-E-STOP	PAC SILO EMERGENCY STOP PUSH BUTTON	PUSH BUTTON	PAC-PLC	E-STOP	N/A	N/A	N/A	VENDOR	VENDOR	VENDOR	40 70 00	1I-601	
LA-147-HORN	PAC SILO ALARM TEST PUSH BUTTON	PUSH BUTTON	PAC-PLC	OFF	N/A	N/A	N/A	VENDOR	VENDOR	VENDOR	40 70 00	1I-601	
AE-191-TSS	POND EFFLUENT TSS ANALYZER ELEMENT	ANALYZER ELEMENT	CP-100	30	0	400	mg/L	CONTRACTOR	BY MANUFACTURER	CONTRACTOR	40 70 00	1I-602	
AIT-191-TSS	POND EFFLUENT TSS ANALYZER TRANSMITTER	ANALYZER	CP-100	-	N/A	N/A	-	CONTRACTOR	BY MANUFACTURER	CONTRACTOR	40 70 00	1I-602	
AE-192-CL	POND EFFLUENT CHLORINE ANALYZER ELEMENT	ANALYZER ELEMENT	CP-100	1	0	20	mg/L	CONTRACTOR	BY MANUFACTURER	CONTRACTOR	40 70 00	1I-602	
AIT-192-CL	POND EFFLUENT CHLORINE ANALYZER TRANSMITTER	ANALYZER	CP-100	-	N/A	N/A	-	CONTRACTOR	BY MANUFACTURER	CONTRACTOR	40 70 00	1I-602	

DIVISION 46 – WATER AND WASTEWATER EQUIPMENT

SECTION 46 05 13 – COMMON MOTOR REQUIREMENTS FOR WATER AND WASTEWATER EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY:

A. This Section includes the following:
   1. Motors and accessories for mechanical, process, and other equipment.
   2. Unless specified or indicated otherwise, motors 1/2-horsepower or smaller shall be single phase and motors 3/4 horsepower or larger shall be polyphase.

B. Items to be provided with Vendor-Packaged systems:
   1. PAC silo arch breaker
   2. PAC silo screw conveyors (2 total) with VFD
   3. PAC silo moisture isolation injector motor

1.03 RELATED REQUIREMENTS:

A. Section 26 05 26 – Grounding and Bonding for Electrical Systems.

1.04 REFERENCE STANDARDS:

A. Applicable Standards:
   1. American National Standards Institute (ANSI).
      a. ANSI B11.19 – Performance Criteria for Safeguarding.
   2. American Bearing Manufacturers Association (ABMA).
      a. ABMA 9 – Load Ratings and Fatigue Life for Ball Bearings.
   3. Institute of Electrical and Electronic Engineers (IEEE).
      a. IEEE 112 – Test Procedure for Polyphase Induction Motors and Generators.
   4. National Electrical Manufacturers Association (NEMA):
      a. NEMA MG 1 – Motors and Generators.

1.05 SUBMITTALS:

A. Submit as specified in Division 01.

B. Product Data: Submit the following as minimum:
   1. Nameplate information consisting of the following:
      a. Manufacturer's name and serial number.
      b. Horsepower output.
      c. Temperature rise and method indicated.
      d. Maximum ambient temperature.
      e. Insulation class.
      f. Rpm at rated load.
      g. Frequency.
      h. Number of phases.
      i. Voltage.
      j. Rated load amperes.
      k. Locked rotor amperes or code letter.
      l. Service factor.

m. Maximum noise level of pump/motor unit (dBA).
n. Efficiency, determined in accordance with IEEE 112, Method B.

2. Dimensions for enclosure and shafts.
3. Weight.
4. Bearing information.
5. Schematic diagrams for motor and specified motor accessories.
6. Certification from motor manufacturer for motors controlled by variable frequency drives that the motor is "Inverter Duty" complies with NEMA MG 1 - Part 31 for all operational load and speed conditions specified and required.

C. Test and Evaluation Reports:
1. Factory test reports.
2. Field test reports.

D. Closeout Submittals: Final documentation shall include the following as minimum:
1. Operation and Maintenance Manuals including the following:
a. Operation and maintenance manuals for all components furnished.
b. Copies of all approved Product Data.
c. Copies of all approved Test Reports.
d. Warranty Information.
e. Contractor Information.

1.06 DELIVERY, STORAGE, AND HANDLING:

A. Motors shall be packaged, skidded and shipped to prevent damage during shipment.
B. Stored motors shall be environmentally protected and maintained according to manufacturer's recommendations.
C. If supplied, energize space heaters to prevent condensation within the motor enclosure.

1.07 WARRANTY:

A. The warranty shall comply with the requirements of SECTION 01 78 36.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

A. Motors:
1. Baldor-Reliance Electric Company.
2. General Electric Company.
3. Marathon Electric Manufacturing Corporation.
4. Siemens Energy and Automation, Inc.
5. TECO-Westinghouse Motor Company.
6. U.S. Motors, Nidec Motor Corporation.

B. Shaft Grounding Ring:
1. AEGIS, Electro Static Technology, Division of Illinois Tool Works Inc.
2. Inpro/Seal, Waukesha Bearings Corporation.
3. Engineer approved equal.

C. Couplings:
1. Rexnord Corporation, Division of RBS Global.
2. Waldron Hartig Machinery Division, Midland Ross Corporation.
3. Engineer approved equal.

2.02 HORIZONTAL SINGLE-PHASE MOTORS:

A. Any motor used in the PAC silo system must be explosion proof and rated for Division II, Class II environments.
B. Rated for 40°C ambient temperature and continuous operation.
C. Voltage: 115V or 115/230V, 60 hertz.
D. RPM: 1750 unless indicated or specified otherwise.
E. Minimum service factor of 1.15.
F. Efficiency: Shall meet the premium efficiency motor standards as defined by NEMA MG 1.
G. Permanent split capacitor designed for low starting torque loads and applications requiring silent operation.
H. Capacitor start designed for high starting torque loads.
I. Shall be protected by an integral thermal-overload protective device in compliance with the NEC. Device shall automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Protection device shall automatically reset when the motor temperature returns to normal range.
J. Adequate to drive equipment over the full operating range without exceeding service factor.
K. Bearings as specified in HORIZONTAL POLYPHASE MOTORS, this Section.
L. Open drip-proof enclosures for clean, dry atmospheres and totally enclosed enclosures for wet or dirty atmospheres.
M. Manufacturer shall prepare surfaces, prime, and finish paint all surfaces with manufacturer's standard coating system. Coating system and color shall be suitable for intended service.
N. Stainless steel nameplate data on enclosure with all lubrication and electrical data.

2.03 HORIZONTAL POLYPHASE MOTORS (LOW-VOLTAGE):

A. Any motor used in the PAC silo system must be explosion proof and rated for Division II, Class II environments.
B. Rated for 460-volt, 3-phase, and 60-hertz operation and operation with variable frequency drive, when indicated.
C. Squirrel cage induction type for across-the-line or reduced voltage starting, as indicated.
    1. Where reduced-voltage starting is indicated or specified the motor shall have torque requirements capable of bringing up the specified load to full speed. The reduced voltage starting shall be limited to 65% of nominal.
D. NEMA Design:
    1. NEMA B: Normal starting duty applications.
    2. NEMA C: High starting duty applications.
E. NEMA Class B insulation except for installations where NEMA Class F is recommended by the manufacturer for the application.
F. When controlled by variable frequency drive motors, shall be “Inverter Duty”, comply with NEMA MG 1 Part 31, and be rated for a minimum of 10:1 speed range for variable or constant torque loads.
G. Efficiency: Shall meet or exceed the efficiency requirements of Xcel Energy’s rebate program. Minimum efficiency shall be 1% greater than the Department of Energy’s Energy Conservation Program: Energy Conservation Standards for Commercial and Industrial Electric Motors.
H. Enclosures:
    1. Totally-enclosed fan-cooled for indoor service, outdoor service or wet areas indoors.
    2. Explosionproof in explosive atmospheres.
I. Horsepower Rating Requirements:

1. Ambient Temperature: 40°C.
2. 1800 rpm unless specified or indicated otherwise.
3. Service factor of 1.15.
4. Adequate to drive equipment without using service factor except in emergency conditions.

J. Bearings:
1. Pre-lubricated ball bearings shielded to prevent entrance to foreign materials.
2. Re-lubrication fittings and flushing system.
3. Minimum L10 bearing life for continuous operation of 100,000 hours to conform to ABMA 9.

K. Sound Pressure Levels (SPL) of the motor shall not exceed the maximum levels as specified in NEMA MG 1 Table 9-1.

L. Manufacturer shall prepare surfaces, prime, and finish paint all surfaces with manufacturer's standard coating system. Coating system and color shall be suitable for intended service.

M. Stainless steel nameplate with all electrical and lubricating information.

N. Accessories:
1. When indicated or specified, provide two normally closed temperature switches embedded in each phase winding for high temperature protection. Switches shall be rated for use with 120Vac.
   a. The temperature at which the contacts open will be chosen by the manufacturer to protect the motor when it overheats.
2. When indicated or specified provide motor space heaters as follows:
   a. Motor space heaters shall be securely attached to the motor windings and sized to maintain the motor internal temperature above the dew point when the motor is not running.
   b. Space heaters shall be silicon rubber type designed for long life and low skin temperature.
   c. Motor space heaters shall be operated at 120Vac.

2.04 BELT GUARDS:

A. Fully enclose belts on both sides except where equipment forms one side.

B. Size to enclose next larger size driven pulley.

C. Two-piece construction when driven equipment and motor are on opposite sides of the belt guard.

D. Provide with tachometer holes and covers.

E. Protective guard shall conform to ANSI B11.19 – Performance Requirements for Safeguarding.

2.05 BELT DRIVES:

A. Single or multiple V-belt.

B. Rated 140% of motor horsepower.

C. Adjustable speed with maximum belt speed of 4,500 fpm.

D. Matched sets of belts on multiple belt drives.

E. Adjustable slide rail motor mounts.

F. Adjustable screw type LVP or MVP for over one groove on motors less than 50 hp.

G. Motors 50 hp and larger may be furnished with two nonadjustable motor pulleys, one for testing and for final operation.

2.06 COUPLINGS:

A. Type as required for specific application as acceptable to Engineer.
B. Protective guard shall conform to ANSI B11.19 – Performance Requirements for Safeguarding.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Install to conform to manufacturer's instruction.
B. Lubricate all bearings, gears and items requiring lubrication before placing equipment in operation.

3.02 FIELD QUALITY CONTROL:

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust motors, assemblies, and associated equipment installations, including connections for motors larger than 50 HP.
B. Field Testing:
   1. Provide manufacturer recommended testing prior to startup of motors.
   2. Testing shall be performed in accordance with IEEE 112.
   3. Check equipment ground to assure continuity of connections as specified in Division 26.
   4. Measure the insulation resistance of the stator winding before applying voltage. Compare this measured value against the manufacturer's value. If there is no insulation resistance value furnished by manufacturer, use the following:

Motor Voltage	Insulation Resistance
600 volts and below	5 megohms

      a. If measured resistance values are lower than above, record room temperature and humidity and submit readings to Engineer before energizing. Dry out motors as required by accepted method of application of external heat, and do not apply voltage to motor until substandard resistance condition is corrected. Megger readings are to be one-minute duration, using a 500V megger for all motors 600V and below.
   5. After the motor is placed in operation, observe the motor for heating at the bearings or windings. If the motor appears to be running hot, notify Engineer.
      a. Note: General purpose motors may reach temperatures up to 176ºF with a room temperature of 104ºF.
   6. Take motor full load amps readings on all phases.
   7. Prepare all results and submit field testing and startup report to Engineer.

3.03 FINISHES:

A. Equipment coatings shall be free from scratches, rust, or other defects.
B. All damaged or defective coatings shall be repaired prior to final acceptance.
C. Field Painting:
   1. Touch Up:

a. Contractor shall prepare surfaces and touch up manufacturer applied coatings as required for any damage during shipment and installation.
b. Field painting shall be performed based on manufacturer's recommended procedures.
c. Motor manufacturer shall furnish Contractor with an adequate quantity of touch-up paint to match the factory applied finish.

END OF SECTION 46 05 13

SECTION 46 36 15 – POWDER ACTIVATED CARBON SYSTEM

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes the fabrication, delivery, installation, and placement into successful operation of one powder activated carbon (PAC) storage silo and feed system.

B. The following equipment, at a minimum, shall be mounted on or in the silo.
   1. One bin vent dust filter.
   2. One silo paddle wheel level indicating system.
   3. One silo load cell system.
   4. One discharge hopper.
   5. One arch breaker unloader.
   6. One knife gate valve with manual operator.
   7. One screw conveyor transfer package.
   8. Silo fill piping (mounted on exterior of silo).
   9. One truck fill panel and truck unloading system.
   10. One 480V control panel.
   11. One low-voltage PLC control panel.
   12. Associated piping and equipment.

C. Provide as specified in Division 01.

D. All equipment and instrumentation shall be pre-wired by Manufacturer.

E. Furnish all special tools required for assembly and operation.

F. PAC to be handled:
   1. Will conform to AWWA B600.

G. Related Work Specified Elsewhere:
   1. Division 01.
   2. Mechanical: Divisions 23.
   3. Electrical: Division 26.
   4. Instruments and Controls: Division 40.
   5. Motors: Section 46 05 13.

1.02 REFERENCES:

A. Applicable Standards:
   1. American Gear Manufacturers Association (AGMA).
   2. American Institute of Steel Construction (AISC).
   3. American National Standards Institute (ANSI).
   4. American Society of Mechanical Engineers (ASME).
   5. American Society for Testing and Materials (ASTM).
   6. Anti-Friction Bearing Manufacturers Association (AFBMA).
   7. Institute of Electrical and Electronic Engineers (IEEE).
   8. National Electrical Manufacturers Association (NEMA).
   9. Steel Structures Painting Council (SSPC).
   10. National Electrical Code (NEC).
   11. Standards of the Hydraulic Institute (HI).
   12. American Water Works Association (AWWA):
      a. B600 – Powder Activated Carbon.

1.03 QUALITY ASSURANCE:

A. In order to unify responsibility for proper operation of the system, all system components shall be furnished and warranted by a single supplier, unless specified to be provided by the Contractor.

B. Factory Testing:

1. Manufacturer shall conduct shop tests as required to guarantee compliance with this Section.

1.04 DESIGN REQUIREMENTS:

A. Design silo, including wall thickness, methods and locations of support, and stiffener requirements. Design shall be sealed by a Colorado Registered Professional Engineer and shall conform to the 2024 International Building Code (IBC) for seismic and wind loads.

B. Silo will be located outside.

C. Wind and Seismic-Restraint Loading:

1. Assigned Risk Category as Defined in the IBC: III.
2. Site Class: D.
3. Design Spectral Response Acceleration at Short Periods (0.2 Second): 0.18 g.
4. Design Spectral Response Acceleration at 1-Second Period: 0.043 g.
5. Seismic Design Category: A.
6. Ultimate Design Wind Speed: 113 mph.

D. All equipment in the storage area of silo shall be rated for Class II Division I hazardous environment.

E. All equipment in equipment room/feed area of silo shall be rated for Class II Division II hazardous environment.

1.05 SUBMITTALS:

A. Submit as specified in Division 01.

B. All information shall be clearly marked showing the manufacturer's name, model number, size, options, etc., for all equipment intended for consideration. All information shall be submitted in a complete package from a single source which addresses each item of the specification and demonstrates adequate compliance. Specified requirements are listed below.

C. Data to be submitted includes, but is not limited to, the following:

1. Equipment Manufacturer's name, type, and model.
2. Protective coating systems.
3. General arrangements, dimensions, and mounting details (including hold-down quantity and details).
4. Design anchor forces.
5. All details for accessories including materials of construction, pressure ratings, and specific information that addresses specified criteria.
6. Pipe material of construction and size (inside and outside diameter).
7. Process and instrumentation diagrams.
8. Rotary Feeder:
   a. Maximum feed rate (lbs. per hr).
   b. Minimum feed rate (lbs. per hr).
   c. Feeder accuracy (±%).
9. Storage Silos:
   a. Storage capacity (lbs.).
   b. Diameter (inches).
   c. Straight wall height (inches).

d. Cone Angle (°).

10. Manufacturer's name and address of local representative.
11. Scope of equipment including all exceptions and/or variations to the specifications listed herein.
12. Electric power requirements, wiring diagrams, schematics, interconnection diagrams, and datasheets for all electrical equipment and devices.
    a. Differentiate between factory and field wiring.
13. Control panel elevation and layout.
14. Area classification plans/identification as applicable.
15. Provide general control description and description of operation.
16. A schedule of maintenance requirements.
17. Any special tools required for assembly and operation.
18. Include a list of recommended spare parts along with current prices and ordering information.
19. Operations and maintenance manuals.
20. Refer to Section 40 67 00 – Process Control Panels and Hardware for additional submittal requirements for the silo control panel.

1.06 DELIVERY AND HANDLING:

A. Provide for delivery, handling, and storage.
   1. As specified in Division 01.
   2. In compliance with manufacturer's instructions.
B. Ship equipment as completely assembled and pre-piped as is possible.
C. Tag each item with Contract number.
D. Store products away from construction traffic and damage.
E. Protect flanged and welded connections with suitable pipe and protection.
F. Notify Engineer and Contractor 30 days prior to shipping.
G. Handle equipment in such a manner as to ensure delivery to final location in sound, undamaged condition. Make satisfactory repairs to damaged equipment and material(s) at no cost to Owner.

1.07 WARRANTY:

A. The equipment Manufacturer shall warrant that all equipment shall be free from defects caused by faulty material or workmanship for a minimum period of two (2) years from the date of Substantial Completion, unless otherwise specified.
B. Warranties shall comply with the requirements of Section 01 78 36.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS:

A. Silo System:
   1. Sodimate, Inc.
   2. Engineer-approved equal.

2.02 GENERAL DESIGN PARAMETERS:

A. One silo to store and feed powder activated carbon (PAC).
B. PAC will be dry fed through a volumetric screw conveyor system and delivered to a nearby batch slurry tank as indicated on Drawings.

C. Capacity:
   1. Silo shall be capable of storing 162,900 pounds of dry PAC.
   2. System shall be capable of feeding 8,300 lbs/hr of PAC.
   3. Maximum Ambient Air Temperature = 110°F; Minimum Ambient Air Temperature = -13°F.

D. All equipment including motors, instruments, etc. within the equipment room of the skirted silo shall be rated for a Class II Div II hazardous environment.

E. All feed system piping shall be SCH 40 Aluminum Pipe with compression couplings, neoprene sleeves. Fittings on PAC slurry piping shall be long sweep radius.

F. Motors shall be as specified in Section 46 05 13 – Common Motor Requirements for Water and Wastewater Equipment unless otherwise stated.

2.03 STORAGE SILOS:

A. To store dry PAC.

B. Designed to be filled with chemical to the top of the tank wall.

C. Provide minimum storage capacity of 162,900 pounds in each silo.

D. Maximum dimensions not to exceed 14 feet in diameter or 62.75 feet in total height (excluding roof mounted equipment).

E. Provide with a minimum 24-inch manhole on top.

F. Provide with connections located as indicated and required for system operation.

G. Shop fabricated.

H. Shall have a live-bottom feeder cone.

I. The storage silo walls, roof, and related accessories shall be of all welded, mild steel construction. Silo roof, straight-wall, cone, and support skirt shall be fabricated of minimum ¼″ ASTM A36 steel.

J. Provide a minimum total wall thickness of 0.25 inches.

K. The storage silo shall be designed to accommodate all dead loads including vibrations from bin activating devices plus a full live load of powder activated carbon having a bulk density of 25 lbs/ft^3 for design purposes.

L. The storage silo shall also be designed to resist stresses produced by wind and/or seismic loading as determined in accordance with the International Building Code.

M. For the purpose of determining stress, all vertical design loads shall be considered acting alone or in combination with these lateral forces. The maximum allowance stresses in any structural steel member shall not exceed those permitted by the latest AISC Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings.

N. All system components shall be factory welded to the maximum extent possible. All welding shall conform to the latest standards of the American Welding Society (AWS) and be performed by certified welders in compliance with AWS D1.1. All weld joints on silo wraps shall be full penetration butt welds both on interior and exterior. Silos with single pass welding on exterior only shall be rejected.

O. The storage bin shall be completely dust-tight and water-tight (weatherproof).

P. All connections to the storage compartments shall be flanged and gasketed connections.
   1. Gaskets shall be of the full faced type of neoprene or approved equal.
   2. All bolted connections shall utilize type 316 stainless steel nuts, bolts, and washers.

Q. Silo Roof:
   1. The silo roof shall be pitched 1:12 for drainage purposes.
   2. The roof shall be designed to support all roof appurtenances, plus superimposed live load of at least 60 pounds per square foot or as specified in the International Building Code; whichever is greater.

3. The bin roof shall have the following connections:
    a. A flanged nozzle type connection of ¼-inch steel plate suitable to support the dust filter.
    b. A 24-inch diameter (minimum) aluminum manway with hinged, gasketed cover, handle-type locking mechanism, and integral pressure / vacuum relief valve.
    c. A flanged nozzle suitable for use with the target box of the chemical supply piping.

R. Railings and kickplates of aluminum construction shall be provided around the perimeter of the storage silo roof. All stairs, ladders, cages, platforms, and handrails shall be of aluminum construction and conform to OSHA and International Building Code standards.

S. Spiral staircase:
1. Silo shall include external, spiral staircase for access to silo roof. Staircase shall be OSHA compliant. Stairs to be installed and maintained according to the manufacturer's instructions.
2. Headroom above spiral stair treads to be minimum 6 ft. 6 in. measured from the leading edge of the tread. There must be a minimum 6 ft. 8 in. clearance measured from leading edge of the tread to any additional overhead obstruction.
3. Stairway landings and platforms to be at least the width of the stair and minimum 30 in. in depth as measured in the direction of travel.
4. When a door or gate opens directly on a stairway, a platform is to be provided. The swing of the door or gate may not reduce the platforms effective usable depth to less than 22 in.
5. Stairs to be minimum clear width of 26 in., maximum riser height of 9.5 in., and minimum tread depth of 7.5 in. measured at a point 12 in. from the narrower edge. Stairs to have uniform tread size.
6. At any point, each stair must be able to support at least 5 times the normal anticipated live load or a concentrated load of 1,000 pounds, whichever is greater.
7. Stairway must be enclosed by stair rail system with handrail on the open side. Handrail to be OSHA compliant.

T. Silo Fill Piping:
1. 4-inch diameter, minimum Schedule 40 carbon steel (ASTM A53, Black) conveying pipe shall be furnished complete with all the necessary harness type couplings, with shoulder harnesses to prevent separation during pressurization.
2. Manufacturer to mount to exterior of silo, extending from bottom of silo to top at fill penetration. Manufacturer to provide a fill-pipe connection point for the Contractor. Connection point to be located at the bottom of the silo, approximately 3-feet above Silo foundation top of concrete.
3. Wherever the filling pipe makes a turn a 4-inch diameter minimum Schedule 40 wear-back elbow, 4-foot radius minimum, shall be provided and installed.

U. Double Steel Doors:
1. Manufacturer shall furnish double steel doors with a minimum 6'-0" x 7'-0" high clear opening for access into the skirted area of the silo. Doors shall be cold rolled stretcher leveled steel. All doors shall be of full flush construction. Doors shall be reinforced, stiffened, insulated, and sound deadened with a solid slab of expanded polystyrene foam permanently bonded to the inside of each face skin.
2. Top and bottom of door shall have 16-gage steel closure channels. Doors shall have beveled (1/8″ x 2″) lock edge.
3. Door Frames: Frames to be fabricated of cold rolled steel minimum 16-gage. All joints shall be die-mitered with integral tabs for reinforcement and interlocking of the jambs to the head. Tack welding or skip welding of frames to jambs shall not be approved. Frames

shall be thoroughly degreased and cleaned of all imperfections before painting. Frames to be reinforced only for surface mounted hardware.

V. The entrance to the PAC silo shall have an OSHA-approved NFPA diamond panel indicating all hazards. Signage to be furnished and installed by the Contractor.

W. The storage silo may be shipped in one or two sections as outlined below.
   1. The storage section shall be structurally designed to store the required chemical. The storage section shall have all components including but not limited to level devices, dust collector blower, and load cells, all of which shall be pre-wired to junction boxes.
   2. The lower equipment room shall house all of the feeding, mixing and metering/delivery equipment including but not limited to an arch breaker unloader, bin vibrators, heater, exhaust fan and silo control panel located on exterior of lower storage area. All of which shall be installed at the factory and pre-piped and pre-wired and hydraulically tested and demonstrated to the customer at the manufacturer's facility. If silo is shipped in two sections, the lower equipment room section shall be supplied with a bolting flange to allow the storage section to bolt to the top of the equipment room section and a junction box to connect the storage section electrical components to the equipment room control panels.

X. Concrete Anchors: Unless noted otherwise by the manufacturer, Contractor shall secure to the foundation using anchors specified on the structural drawings.

Y. Anchor Ring: the silo shall have an anchor ring which shall be welded into the lower skirt section of the silo. The anchor ring shall be welded continuously around both top and bottom of silo support skirt. Skip welding or welding of only one surface shall not be acceptable.

Z. Wall Penetrations: All wall penetrations shall have a minimum thickness of ¼″ for all square or rectangular shapes, all round penetrations shall not be less than schedule 40. All penetrations shall be completed seal welded.

AA. Manufacturer to provide a minimum of one grounding lug suitable for a #4/0 cable connection on silo exterior. Coordinate location with installing Contractor.

BB. The system shall accommodate all feed equipment within the skirted silo.

CC. Lightning Protection System:
   1. Furnish a Master Label Certificate issued by Underwrites' Laboratories, Inc. for the system and attach to the base of the structure.
   2. Provide a lightning protection system or provide documentation that the silo and stand are adequate to be part of the lightning path to ground.
   3. All portions of the system shall be galvanically compatible to the building material to which they are to be attached.
   4. All system components shall be, to the maximum extent possible, the product of a single manufacturer. All components shall be type Class I as required by NFPA 780.

2.04 TRUCK UNLOADING SYSTEM:

A. Fill System Pipe Adapter: A 4-inch bronze Camlock type adapter shall be mounted on the fill pipe at the silo feed panel. A bronze dust cap and chain shall be provided. A slot shall be milled in the dust cap to prevent operation of the limit switch while fill system is not in use. An engraved phenolic nameplate shall be provided for the fill line connection complete with chain and properly displayed so that the filling truck operator can see while filling the silo.
   1. Conveying Pipe (By Contractor): 4-inch diameter, minimum Schedule 40 carbon steel (ASTM A53, Black) conveying pipe shall be provided by Contractor. Route from remote fill station to Silo connection point provided by Manufacturer at the bottom of the silo.

2. Furnish complete with all the necessary compression couplings to prevent separation during pressurization. Couplings to be 4.5-inch galvanized compression couplings with neoprene sealing gaskets. Include stainless steel grounding strap or hardware.
3. Adapters to be 4-inch semi-steel (cast iron/steel alloy).
4. Secure to concrete with brackets as indicated in Drawings. Brackets to be 4" EATON B-line B3180-4 SS6 with AISI TYP 316 SST material, or engineer approved equal. Install 1/8" EATON B-line B1999 Vibra-Strip or engineer approved equal between the pipe wall and bracket.
5. Wherever the filling pipe makes a turn, provide a 4-inch diameter minimum Schedule 40 carbon steel (ASTM A53, Black) wear-back elbow with 48-inch radius and 9-inch tangents.

2.05 FEEDER:

A. Design Requirements:
1. Sized as required for batch system supplying up to 8,300 pounds of carbon per hour.
2. Shall be volumetric type feeder capable of handling specified material.
3. Completely enclose the feeding mechanism so as to restrict the passage of dust into the driving mechanism.
a. Provide removable cover with hinged or removable doors to allow access to all parts.
b. Shaft seal shall include both stationary and rotating faces, the using of packing rings will not be acceptable.
4. Noise level of installed feeder shall not exceed 80 dBA weighted average, measured three feet from the surface.

B. Feeder Construction:
1. Housing and auger of 304 stainless steel.
2. Discharge spout of 304 stainless steel and PVC.
3. Provide flexible connection of rubberized fabric at the inlet of the feeder.

C. Volumetric Feeder System Components:
1. Auger-Type Feeder.
a. Shall be electrically-driven with a variable frequency drive.
b. Shall include a mechanical clutch or shaft zero-speed switch to prevent breakage of auger with an alarm should loading on screw become excessive.
c. Auger shall be solid-shaft. Auger to include internal collar with edge of flighting extending to walls of channel. Auger shall not permit loose PAC to travel freely through conveyor. Pigtail type auger is prohibited.
d. Auger shall be an abrasion-resistant material such as high chrome or Ni-hard steel.
2. Feed System shall be designed to maintain feed rate to within plus or minus 1% of setting throughout the specified operating range.
3. All feed system components in contact with chemical shall be constructed of stainless steel, unless otherwise specified. All mild steel shall be factory coated.

D. Motor shall be as specified in Division 46.

2.06 BIN VENT-DUST FILTER:

A. Equipment:
1. WAMFLO ATEX Round filter or approved equal.
2. Filter must accept Donaldson Torit part number P034301.

B. General Requirements:

1. Provide one open-bottom, flange-mounted bin vent dust collector suitable for outdoor installation and complete with the following:
   a. Dust filter bags.
   b. Dust filter bags cleaning shaker mechanism.
   c. Weather hood over the collector vent.
2. Design for use with the following chemical:
   a. PAC conforming to AWWA B600.
3. Provide contacts, wired to terminal blocks on the local control panels specified this Section and Division 40, for remote alarm of chemical silo dust collector trip.
4. Provide neoprene gaskets for all equipment interface connections and bolted joints.

C. Bin vent-dust filter construction and design details:
1. Mounted on top of the silo.
2. Designed to be bolted to the silo as indicated.
3. Provide mounting flanges and gaskets.
4. Provide grid under collector to prevent filter bags and tools from dropping into the silo.
5. Bin vent-dust collector housing shall be 304 SST.
   a. Minimum filter surface area of 16 m^2, with media being water repellent, oil repellent, and antistatic.
   b. A minimum clearance of 36 inches shall be provided for maintenance purposes.
6. Dust filter bags:
   a. Design for a maximum air to cloth ratio of 4.0 cfm per square foot of active cloth area based on pneumatic truck blower capacity.
   b. Filter media shall be designed for a maximum operating temperature of 140°F.
   c. Bag and bag cleaning system shall be of a type having a minimum of three-year average bag life before replacement in similar service.
   d. Provide one spare bag for each ten bags furnished.
7. Filter bags shall be immediately cleaned upon unit shutdown via mechanical shaking initiated by a solid-state timer or the system controller.
8. Cleaning shake mechanisms to be equipped with explosion-proof motors suitable for 460V, 3-phase, 60-Hz electrical service.
9. Provide control of dust filter via either the main control panel or a dedicated local control panel.
   a. Local control panel: A UL-Listed control panel applicable for the environment with hinged access door shall be provided and shall include the fan and shaker motor starters, overloads, control circuit transformers, fuses, and associated controls.

2.07 ARCH BREAKER HOPPER:

A. Silo shall come equipped with an arch breaker unloader extending into the live-bottom silo cone.
B. The arch breaker shall have minimum diameter of 15-inches.
C. The arch breaker shall include a transparent inspector door and window.
D. The arch breaker shall be controlled from the feeder circuit and operate only when the feeder is in operation.
E. The arch breaker shall operate on 480V, 3-phase, 60 Hz explosion proof motor suitable for operation in hazardous environment.

2.08 KNIFE GATE VALVE:

A. Provide a manually operated knife gate with handwheel or chain wheel operator.
B. Externally air and watertight.

C. Mounted between the live-bottom of the silo and the arch breaker.
D. Provide positive shutoff of material flow.
E. Self-cleaning, non-clog type.
F. Gate capable of retracting out of the material flow path.
G. Stainless-steel gate.
H. Beveled, knife-like edge gate.
I. Minimum eight-inch diameter.

2.09 VOLUMETRIC SCREW CONVEYOR TRANSFER SYSTEM:

A. General:
   1. Provide screw conveyor feed system, piping, and other associated equipment required to deliver dry chemical from the silo the slurry basin. Contractor to provide any piping outside of the skirted silo.
   2. Feed System shall be designed to maintain feed rate to within plus or minus 1% of setting throughout the specified operating range.
   3. All feed system components in contact with chemical shall be constructed of stainless steel, unless otherwise specified. All mild steel shall be factory coated.

B. Design Requirements:
   1. Sized as required for batch system supplying up to 8,300 pounds of carbon per hour.
   2. Shall be volumetric type feeder capable of handling specified material.
   3. Completely enclose the feeding mechanism so as to restrict the passage of dust into the driving mechanism.
      a. Provide removable cover with hinged or removable doors to allow access to all parts.
      b. Shaft seal shall include both stationary and rotating faces, the using of packing rings will not be acceptable.
   4. Noise level of installed feeder shall not exceed 80 dBA weighted average, measured three feet from the surface.

C. Volumetric Feeder Construction:
   1. Housing and auger of 304 stainless steel.
   2. Discharge spout of 304 stainless steel and PVC.
   3. Provide flexible connection of rubberized fabric at the inlet of the feeder.
   4. Auger shall be solid-shaft. Auger to include internal collar with edge of flighting extending to walls of channel. Auger shall not permit loose PAC to travel freely through conveyor. Pigtail type auger is prohibited.

D. Volumetric Feeder System Components:
   1. Auger-Type Feeder.
      a. Shall be electrically-driven with a variable frequency drive.
      b. Shall include a mechanical clutch or shaft zero-speed switch to prevent breakage of auger with an alarm should loading on screw become excessive.
      c. Conveyor shall operate on 460V, 3-phase, 60 Hz motor rated for Class II Division II hazardous environment and altitude.
      d. Conveyor shall be supplied with an anti-blockage switch in the event the outlet is clogged.
   2. Moisture Isolation Injector:
      a. Provide moisture isolation injectors suitable for application and contact with specified dry chemical.

b. Injectors shall operate on 460V, 3-phase, 60 Hz motor rated for hazardous environment and altitude.
c. Injectors to be 304 stainless steel.

2.10 POWER AND CONTROLS:

A. All electrical equipment, wiring, raceways, grounding, supports, identification, and installation associated with the PAC system shall comply with the requirements of DIVISION 26.
B. All controls equipment associated with the PAC system shall comply with the requirements of DIVISION 40.
C. One 480VAC 3-phase power supply will be provided for the PAC system to the 480V PAC Panel. The PAC system shall then be able to distribute the power for all ancillary electrical and controls equipment.
D. The PAC feed system shall be provided with two NEMA 4X stainless steel panels, one for 480V power components including VFDs and motor starters, and the other containing controls and PLC components. An additional NEMA 4X stainless steel truck unloading panel shall be provided by manufacturer and mounted by Contractor approximately 50 ft. from exterior of silo.
E. Two silo mounted junction boxes shall be installed at the silo and shall act as the point of connection for all cabling between the control panel and the silo. One junction box shall be for 480V and 120V power, and one for low voltage controls and instrumentation. All connections within the junction boxes shall be made using terminal blocks.
F. PAC system shall be supplied with integrated controls using a Schneider Electric Modicon M580 PLC, or Engineer Approved Equal, to control and monitor status of supplied equipment (i.e. PAC PLC control panel). The PLC shall be programmed to communicate control and status points with the plant control system via an Ethernet Modbus TCP network. Coordinate final communications protocol selection with the Systems Integrator based on the plant control system PLC platform supplied.
G. The silo control and monitoring components shall be installed and factory wired to the specified silo mounted junction boxes.
H. All building system components including lights, heaters, exhaust fans, and receptacles shall be installed and factory wired to the specified silo mounted junction boxes.
I. All electrical components and equipment including installation methods shall comply with Division 26.
J. Electrical installation within classified spaces shall meet all NEC requirements for Class 2 spaces at a minimum.
K. The PAC system manufacturer shall provide all control components and instruments as specified herein as a minimum.
L. Truck Unloading Panel (PAC-LCP):
    1. The truck unloading panel shall be a NEMA 4X stainless steel enclosure and be installed approximately 50-feet away from the silo. Enclosure and associated accessories to be provided by Manufacturer and wired by Contractor.
    2. The panel shall be powered from the 480V control panel and the panel controls shall be integrated into the PLC control panel (PAC-PLC).
    3. The panel shall contain all required components for complete control and monitoring of the bin vent system, and shall contain all required components for monitoring of the silo level.
    4. As a minimum the following selector switches, pushbuttons, indicating lights and displays shall be mounted on the door of the panel:
        a. Start/timer switch button for bin vent.

b. High, low, and low-low level alarm indicating light; connected from paddle level switches.
c. Truck fill connection limit switch.
d. All devices shall be factory installed, wired, and tested. Terminal blocks shall be provided and labeled as required for power, control, and instrumentation.

M. Silo Mounted Junction Boxes:
1. The silo mounted junction boxes shall be NEMA 4X stainless steel enclosures and contain terminal blocks for connection to the main control panels.
2. Provide adequately sized boxes for termination of conduits indicated and required.

N. 480V Control Panel (PAC-MCP):
1. The 480V control panel shall be NEMA 4X 304 stainless steel and mounted outside of the silo.
2. The 480V control panel shall supply power to all silo equipment and building systems and shall be the single point of connection for power.
3. The control panel shall accept a single point 480V, 3-phase power supply connection.
4. The control panel shall be provided with all necessary field terminal blocks for connection to silo mounted power junction boxes.
5. At a minimum, the following components shall be installed in the panel:
a. Door interlocked main circuit breaker disconnect.
b. Motor starters and variable frequency drives.
c. Required circuit breakers, and other 480V devices.
6. All devices shall be factory installed, wired, and tested. Terminal blocks shall be provided and labeled as required for power, control, and instrumentation.
7. Panel shall be provided loose, for mounting outside the hazardous environment.

O. PLC Control Panel (PAC-PLC):
1. The PLC control panel shall be NEMA 4X 304 stainless steel and mounted outside of the silo.
2. The PLC control panel shall be the single point of connection for data interfaces with the plant.
3. The control panel shall accept a single 120V, 1-phase power supply connection supplied from the vender provided 480V control panel.
4. The control panel shall be provided with all necessary field terminal blocks for connection to silo mounted power, control, and instrumentation junction boxes.
5. The control panel shall contain all required components for complete control and monitoring of the PAC system, building components, and associated equipment. At a minimum, the following components shall be installed in the panel:
a. Door interlocked main circuit breaker disconnect.
b. Programmable Logic Controller (PLC) shall be Schneider Electric M580 PLC or Engineer-approved equal. Equal must be compatible with the Owner's cybersecurity license. Coordinate with the Owner and refer to Section 40 67 00.
c. Operator Interface Terminal. Refer to Section 40 67 00.
d. Panel Mounted Ethernet Switch. Refer to Section 40 66 00.
e. Required circuit breakers, control relays, power supplies, selector switches and indicating lights.
6. All devices shall be factory installed, wired, and tested. Terminal blocks shall be provided and labeled as required for power, control, and instrumentation.
7. Panel shall be provided loose, for mounting outside the hazardous environment.

a. As a minimum the following selector switches, pushbuttons and indicating lights shall be mounted on the door of the control panel:
   (1) Local/Off/Remote switch.
   (2) Power On indicating light.
   (3) All other indications for running and failure shall be integrated into OIT unless recommended otherwise by system manufacturer.

b. Additional status points and adjustment of set points and operating parameters shall be available via the operator interface touchscreen. As a minimum the following parameters and status points shall be viewable and/or adjustable via the operator interface:
   (1) Run Status indication for all equipment.
   (2) Volumetric Feeder Feed Rate status and control.
   (3) Silo Weight.
   (4) Failure Alarms. (Specific alarm descriptions shall be identified for each failure).
   (5) Alarm Set Points.
   (6) Alarm History Log.
   (7) Speed readout for the feeder and blower.
   (8) All other points required for complete control and monitoring of the system.

8. PAC Silo Communication:
   a. The quantity of PAC in the silo shall be monitored by the associated weight instrumentation and manufacturer provided control panel. The levels shall be communicated to the plant control system.
   b. The bin activator shall be controlled by the manufacturer provided control panel.
9. Bin Vent Dust Filter Communication:
   a. The filter shall operate when the fill connection is in use, when initiated by operator, and at regular intervals (if required) as determined by system manufacturer.
10. Volumetric Feeder Communication:
   a. The PAC feeder shall be controlled at the associated control panel.
   b. Manufacturer provided PLC shall be programmed to control dry PAC feed rate into the slurry basin. PAC feed rate shall be adjustable via the operator workstation.
   c. Local Control:
      (1) When the PAC feeder is in LOCAL control, starting and stopping of the feeder and the feed rate shall be controlled at the associated manufacturer provided main control panel OIT.
         (a) Manual Control Mode:
            1). Starting and stopping of PAC feeder initiated by the operator at the main control panel OIT.
            2). The operator shall set the feeder feed rate in units of pounds per hour for the PAC feeder.

P. Variable Frequency Drives:
1. Submittals:
   A. In addition to the requirements of SECTION 01 33 00, submittals shall also include, but not be limited to, the following:
      (1) Product Data:
         (a) Product specification datasheets.
            1). Dimensions and weights.
            2). Current and Voltage ratings.

3). Short circuit ratings.
4). Proof of any NTRL testing and certification of the equipment for the services as specified.
5). Detail features, characteristics, ratings, and factory settings.

(b) Installation and operation instructions.

(2) Shop Drawings: Submit Shop Drawings of motor controllers
(a) Serial number.
(b) Nameplate data.
(c) Wiring Diagrams: Submit power and control schematic and wiring diagrams for motor controllers and contactors. Differentiate between portions of wiring which are manufacturer factory installed and portions which are field installed.
(d) Factory Test Reports.

2. Factory Tests:
   a. The manufacturer shall conduct tests according to industry standard requirements.
   b. Perform factory tests on all VFD assemblies to assure that all devices and systems are in proper working order before delivery to jobsite.
   c. Test all power, control and communication systems for proper operation.
   d. Simulate actual system operation.
   e. Submit test reports as specified in Division 01.
3. VFDs shall be manufactured, assembled, tested and provided with a UL label.
4. All new VFDs on the project shall come from a single manufacturer for ease of Owner maintenance.
5. Subject to compliance with requirements, provide VFDs from one of the following manufacturers:
   a. Eaton.
   b. Allen-Bradley.
   c. ABB.
   d. Schnieder Electric.
   e. Approved Engineer Equivalent.
      (1) The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Engineer ten (10) days prior to bid date.
6. Provide heavy-duty/constant-torque Variable-frequency motor controllers (VFDs), consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of a three-phase induction motors by adjusting output voltage and frequency.
   a. Capable of communication protocol and being controlled across the PCS network.
7. Motor Compatibility:
   a. Motor life expectancy shall not be compromised in any way by operation with the VFD system. The VFD shall provide motor overload protection in any operating condition.

b. The VFD output waveform shall be suitable for operating a squirrel cage induction motor without derating or requiring additional service factor.
c. The system design shall not have any inherent output harmonic resonance in the operating speed range.
d. The VFD output shall produce no electrically-induced, pulsating torque to the output shaft of the mechanical system eliminating the possibility of exciting a resonance caused by VFD induced torque pulsations.
e. The VFD shall protect the motor from high-voltage dv/dt stress which would cause insulation breakdown of an "inverter ready" motor. If the VFD requires an output filter to meet this requirement, it shall be an integral part of the VFD system and be included within the VFD enclosure.
f. Provide VFDs with dV/dT output filters for motor lead lengths longer than 200’.
g. Provide VFDs with 3% load reactors for lead lengths between 100’ and 200’.
h. Provide VFDs with no output filtering for lead lengths less than 100’.

8. All protective devices and breakers as specified.
9. Designed for heat dissipation.
10. UL listed enclosure.
11. All soft communication interface equipment.
12. Any third-party certification, safety or protection requirements shall be applied to the Integrated Package as a whole. Certification or protection of only system elements or individual components by themselves is not acceptable.
13. The VFD system shall be delivered to the site pre-assembled and wired with all specified interconnecting wiring and cable.
14. Complete instructions for handling and storage shall be provided prior to delivery of the equipment. All equipment shall have adequate provisions for handling.
15. VFDs delivered before the installation location is prepared shall be stored according to the manufacturer’s instructions and in a conditioned space to avoid condensation, dust, and other environmental contaminants.
16. VFD construction:
    a. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
    b. Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection for motors as specified in in Divisions 33, 43, and 46.
    c. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.
    d. Microprocessor based and utilized Pulse Width Modulation (PWM) for speed control of an induction motor.
    e. Insulated Gate Bipolar Transistors (IGBT’s).
    f. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.
    g. Adjustable speed acceleration and current limits.
17. VFD Performance requirements:
    a. Power Factor: not less than 95% from 30 to 115% speed.
    b. Service factor: 1.15
    c. The VFD shall be capable of producing a variable AC voltage/frequency output to provide continuous operation of a standard induction motor over a 5-100% speed range with the following operational requirements:
        (1) Output waveform shall be suitable for operating a squirrel cage induction motor without derating or requiring additional service factor.

(2) Input Voltage:
(a) 480 VAC, 3-Phase.
1). Output Voltage:
(b) 480 VAC, 3-Phase
1). Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFD input voltage rating.
(3) Input AC Voltage Unbalance: Not exceeding 5 percent.
(4) Input Frequency Tolerance: Plus or minus 3 percent of VFD frequency rating.
(5) Minimum Efficiency: 96 percent at 60 Hz, full load.
(6) Minimum Displacement Primary-Side Power Factor: 96 percent under any load or speed condition.
(7) Minimum Short-Circuit Current (Withstand) Rating:
(a) Solids Removal Control Panel: 22 kA.
(b) All others: 65kA
(8) Ambient Temperature Rating: Not less than 32 deg F (0 deg C) and not exceeding 104 deg F (40 deg C).
(9) Humidity Rating: Less than 95 percent (noncondensing).
(10) Altitude Rating: as required by the Site Conditions.
(11) Vibration Withstand: Comply with NEMA ICS 61800-2.
(12) Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
(13) Speed Regulation: Plus, or minus 5 percent.

18. VFD & motor protection, include all controls necessary to indicate and alarm if a protection has tripped and which protection tripped:
a. Surge Suppression: Factory installed as an integral part of the VFD, complying with UL 1449 SPD, Type 1 or Type 2.
b. Surge Suppression: Field-mounted surge suppressors complying with Section 26 43 13 "Surge Protection for Low-Voltage Electrical Power Circuits," UL 1449 SPD, Type 2.
c. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
d. Under- and overvoltage trips.
e. Inverter overcurrent trips.
f. VFD and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFDs and motor thermal characteristics, and for providing VFD overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
g. Critical frequency rejection, with three selectable, adjustable dead bands.
h. Instantaneous line-to-line and line-to-ground overcurrent trips.
i. The VFD system shall be protected from damage due to the following, without requiring an output contactor:
(1) Loss-of-power protection due to opening of the overcurrent protection device.
(2) Loss-of-any-phase protection.
(3) Reverse-phase protection.
(4) Short-circuit protection.
(5) Motor regeneration due to backspin or loss of VFD input power.
j. The VFD shall be able to withstand the following fault conditions without damage to the power circuit components:
(1) Failure to connect a motor to the VFD output.

(2) VFD output open circuit that may occur during operation.

k. Motor-overtemperature fault.

19. Control signals shall meet noise immunity and safety requirements as defined by IEEE 519.

2.11 PROCESS DESCRIPTIONS:

A. Description of Operation:

1. The complete system shall be controlled by a manufacturer provided control panel equipped with a PLC as specified above. All I/O and operator setpoints required for REMOTE control as described herein shall be communicated between the PAC system PLC and the plant control system PLC via hardwire and over the specified Ethernet network.
2. Contractor to coordinate hardwired signal requirements with Owner and PAC silo manufacturer.

B. Refer to P&IDs or Supplier control narratives for each systems process programming requirements.

C. Truck Unloading Panel (PAC-LCP):

1. Loading of the silo shall initiate when PAC truck supplier connects to vendor-provided truck fill panel junction box (PAC-LCP).
2. Supplier to push HS-148-TIMER (TIMER), located on PAC-LCP, to initiate Silo dust filler (PAC-FLT-144) and begin fill.
3. The filter shall operate 30 to 50 seconds after loading and operate for a duration of 1 minute.
   a. Truck supplier to repeat process until fully unloaded.
4. Paddle level switches shall connect to indicator light display at the PAC-LCP and convey the following:
   a. LS-149C to indicate low-low level (silo empty).
   b. LS-149B to indicate low level.
   c. LS-149A to indicate high level (PAC truck stop unloading). If the PAC reaches the high-level switch setpoint, an alarm with signal and the loading will stop.

D. PLC Control Panel (PAC-PLC):

1. PAC Dispensing Sequence:
   a. To Start: Start the injector MII-135. After an operator-adjustable delay of 5 to 20 seconds, the conveyor SC-134 starts. After an operator-adjustable delay of 5 to 20 seconds, arch breaker AB-132 and metering conveyor SC-133 start.
      (1) Following the request to start up the arch breaker and metering conveyor, if no rotation information is received after a few seconds, an alarm will signal and stop the installation.
      (2) If no rotation information is received from the low-low level switch LS-149C, the system will stop.
      (3) A thermal overload default on the motors (YA-132-OL, YA-133-OL, YA-134-OL, and YA-135-OL) will stop the system.
      (4) If a pressure exceedance is indicated from anti-blockage switches PS-138, PS-140, and PS-141, the system will stop.
   b. To Stop: From the stop signal, the arch breaker, metering conveyor, conveyor, and injector are stopped simultaneously.
   c. Owner-preferred Integrator to incorporate dispensing sequence for PAC silo into control sequence for existing PAC Pretreatment Facility basin in SCADA system

per Section 40 61 96. System to dispense at a feed rate of 8,3000 lbs/hour for a duration of 4.8 hours (288 minutes), then issue stop signal.

2. Frequency Inverter:
   a. The frequency inverter allows the screw's rotation speed to be adjusted using frequency between 30 and 60 Hz. If the frequency inverter is shut down, the conveyor SC-134 and the metering conveyor SC-133 dosing unit must be stopped. A safety device internal to the frequency inverter stops all the installation. In this case, a relay with fixed threshold must be used. The acceleration and deceleration ramps of the frequency inverter must be adjusted to 0.5 and 0.5 seconds.
3. Weight Elements:
   a. Load cells installed on skirt of silo shall monitor the weight of PAC stored inside the silo, in pounds (lbs).
   b. Four load cells shall be provided and distributed equally around the circumference of the skirted silo: WE-142A, WE-142B, WE-142C, and WE-142D.
   c. Load cells shall be hardwired to NEMA 4X junction box. Junction box to contain weight summing card and transmitter (WQ/WIT-143).
   d. Summed silo weight to be incorporated into treatment plant SCADA system. Owner's preferred Integrator to program weight alarms in SCADA system per Section 40 61 96.
4. Panel Controls:
   a. An emergency stop (E-STOP) button shall be provided through HS-145 capable of halting the full PAC system.
   b. A system alarm (HORN) shall be provided through LA-147 and shall trigger when there is a fault, high level, low level, overload, or emergency stop activation.
   c. A stacklight (R/A/G) shall be provided through YL-146. Lights shall indicate system status as follows:
      (1) Green: PAC system available and running normally
      (2) Amber: Attention required, such as low inventory or system standby
      (3) Red: Fault, trip, or equipment unavailable

2.12 INSTRUMENTS:

A. Refer to Section 40 70 00 for acceptable manufacturers and instrument specifications.
B. As a minimum, provide the following instruments for control and monitoring of the feed system.
C. Load Cells:
   1. Provide a load cell leg pad for monitoring of PAC weight across the silo for each silo leg or provide load cells at locations around the skirt sufficient to accurately measure the silo's weight and determine the weight of stored PAC.
   2. Load cells to be capable of accurately measuring the weight of stored PAC after accounting for the empty silo weight.
   3. Load cells to be double-ended beam and made of alloy steel construction.
   4. Provide junction box with summing card and weight indicator and analog output to be integrated in the silo control panel.
   5. Provide at minimum the following spare parts, and additional spare parts as recommended by the manufacturer:
      a. Mounting hardware
      b. Loading brackets
      c. Bolts and washers

d. If routine calibration requires removing a load cell after the system is placed in service, provide one spare load cell compatible with the installed units.

D. Level Switches:
1. Provide rotating paddle type high-level, intermediate-level (reorder), and low-level switches for monitoring of level of material within the silo.

E. Pressure Relief Valves:
1. Provide a pressure relief valve on roof of silo.

F. Temperature Switch:
1. Provide a low temperature switch to alarm if a low temperature is detected in the equipment room.

G. Limit Switch:
1. Provide a pipe mounted limit switch to detect when a truck is connected to the fill line.

2.13 HEATING, VENTILATING, PLUMBING, INSULATION, AND LIGHTING SYSTEMS:

A. Ventilators: One ventilator in the storage silo shall be provided complete with manual operators. Each unit shall be equipped with an insect screen.

B. Power Vents: A thermostatically controlled power vent shall be furnished in the silo equipment areas. Thermostats shall open or close whenever temperature reaches a predetermined set point and shall be adjustable from 30°F to 100°F. Vents shall be corrosion resistant, of heavy-duty construction, and rated for a Class II Division II hazardous environment.

C. Insulation:
1. The insulation shall be closed cell, flexible, rigid insulation on the interior skirted portion of the silo and underside of cone. Insulation shall comply with applicable minimum R-values.
2. Where required, liners shall be supported by a series of 3″ x 3″ x 3/16″ angle rings welded into the silo inner skirt and located on centers not more than 36″ apart. Steel liner shall be welded to these angle rings and properly sealed to prevent leakage. All flanges required for exhaust fans, ventilators, etc., will be framed around this silo liner and seal welded in place to prevent moisture from entering.

D. Lighting:
1. Interior Lighting:
a. Provide LED interior lighting within the silo. Lighting in the building shall be rated for the hazardous environment. Minimum average foot candle level shall be 40 fc at the floor, 4000K color temperature. Emergency egress lighting shall comply with NFPA 101 requirements.
b. Light switches shall be rated 120Vac, 20A, heavy-duty type. Locate the switch on the silo interior adjacent to door on handle side. Light switch and box shall be rated for the hazardous environment.
c. The silo manufacturer shall provide support provisions for mounting interior lighting as required.
2. Exterior Lighting:
a. Provide LED exterior lighting on the exterior face of the building. At least one fixture shall be provided approximately 6″ above each man door. Light fixtures shall be full cut-off design and be dark skies compliant. Color temperature shall be 3000K. Lumen package shall provide a minimum of 3000 lumens output. Fixture options shall include field adjustable output control.
b. Exterior lighting shall be provided with an integral photocell.

E. Receptacles:
1. Interior Receptacles:

a. At least one (1) duplex, general purpose convenience receptacles shall be furnished about the periphery of the interior of the silo.
b. Interior receptacles shall be heavy duty, GFCI type. Rated 20A, 120Vac. Interior receptacles shall be Class 2 rated as required per area classification.

2. Exterior Receptacles:
a. At least one (1) duplex convenience receptacle shall be provided on the exterior of the enclosure. Receptacles shall be placed so they are easily accessible and not located directly under any wall mounted equipment.
b. Outdoor receptacles shall be heavy duty type, weatherproof while-in-use, GFCI type. Rated 20A, 120Vac. Outdoor weatherproof while-in-use cover shall be constructed of cast aluminum for the body cover.

F. Electric Unit Heaters:
1. Horizontal Discharge Type.
2. Shall be capable of maintaining silo skirt enclosure above 40°F with an outside temperature of 0°F.
3. Shall be rated for a Class II Division II hazardous environment.
4. Fans and motors:
a. Provide wire fan guards.
5. Units shall conform to UL 1096 for zero clearance to combustible materials.
6. All factory wiring shall be Glass-Teflon insulated with nickel-plated copper conductors rated for 250°C.
7. Arrange unit for 480V, 3-phase power supply.
8. Fintube elements shall be spiral metal sheath Fintube heating elements with built-in overhead protection.
9. Heavy gage steel cabinet with baked-on enamel finish.
10. Individually adjustable discharge louvers to direct air flow.
11. Unit shall be complete with unit-mounted thermostat.
12. Provide mounting bracket.

2.14 SURFACE PREPARATION AND PAINTING:

A. All stainless-steel surfaces shall be left unpainted.

B. Provide the following Tnemec system or Architect approved equal meeting the design criteria below. All painting of silos and other equipment and assocated silo appurtenances integral to the PAC feeding system shall be done at the silo manufacturing site. Equipment Supplier shall provide touch up paint to the Contractor for field touch up. The Equipment Supplier shall prepare all painted surfaces of the silo as follows:
1. All interior steel surfaces of the silo (except where insulated):
a. Surface Preparation: In accordance with SSPC-SP10/NACE 2 Near White metal cleaning and approved materials removal and containment plan. Clean and dry surface per ASTM D4258.
b. Primer: Series V69 Hi-Build Epoxoline II @ 4.0-6.0 mils
c. Stripe: Series V69 Hi-Build Epoxoline II @ 2.0-4.0 mils
d. Finish Coat: Series V69 Hi-Build Epoxoline II @ 4.0-6.0 mils
2. Insulation interior surface:
a. Surface Preparation: Clean and dry
b. Primer: Series 151-1051 Elasto-Grip FC @ 0.7-1.5 mils D.F.T.
c. Finish Coat: 1 coat of Series V69 Hi-Build Epoxoline II @ 4.0-8.0 mils D.F.T.
d. Total D.F.T. of 6.5-11.0 mils minimum.

3. All exterior surfaces of the silo:
    a. Surface Preparation: In accordance with SSPC-SP10/NACE 2 near White metal. Clean and dry surface per ASTM D4258.
    b. Primer: Series 90-97 Tneme-Zinc @ 2.5-3.5 mils
    c. Intermediate Coat: Series V69 Hi-Build Epoxoline II @ 4.0-6.0 mils
    d. Finish Coat: Series 1095 Endura-Sheild @ 2.0-3.0 mils D.F.T.
    e. Total D.F.T. of 6.5-9.5 mils minimum.

C. All surfaces of the silo shall be touch-up painted in the field by the installation contractor.

D. All equipment other than the silo shall be painted with the Supplier's standard paint system.

PART 3 - EXECUTION

3.01 SPECIAL CONTRACTOR INSTALLATION INSTRUCTIONS:

A. Manufacturer shall furnish each bidding contractor a listing of any special installation instructions required for overall system installation. It shall be the Contractor's responsibility to familiarize itself with any special installation requirements.

3.02 MANUFACTURER'S FIELD SERVICES:

A. The services of a manufacturer's qualified technical representative (field personnel) shall be required at the site for installation service, startup service, and training of Owners staff for proper operation of system and as required. Field personnel shall be required for on-site load cell calibration.

B. The manufacturer's field personnel shall demonstrate experience with installation, start-up, and operating of systems of comparable size, application, and complexity.

C. In addition to the time necessary to complete the requirements established elsewhere in these specifications and the Contract Documents, the field personnel shall be present at the Project Site during the minimum times as follows:
    1. Minimum of three trips to the jobsite, not to exceed a total of nine eight-hour working days for services as listed herein with the specific provisions as follows.
    2. Training shall include a minimum of two working days for field training of Owners Staff and shall generally include, but not be limited to, the following:
        a. System operational theory and background.
        b. Automatic control.
        c. Manual control.
        d. Required maintenance.
        e. System troubleshooting.
    3. Contractor shall coordinate between manufacturer's representative, Owner, and Engineer to schedule startup and training services.
    4. Owner may video record training sessions.

3.03 PERFORMANCE TESTS:

A. Shall be as specified in Division 01 and in paragraph 3.02 above.

B. All testing and inspections shall be performed by the manufacturer's representative per the manufacturer's recommendations and requirements and as specified. Testing shall include but not be limited to:
    1. Factory Test:
        a. Factory test performance of all components as a functioning system prior to shipment.

b. Conduct such operational tests as necessary to determine that the performance of equipment and controls are as specified.
c. Complete calibration of blower.
d. Verify all factory settings for pressure relief and pressure gages.

2. Field Test:
a. After installation and inspection is complete, Manufacturer's field representative shall perform startup testing as required to confirm system performance.
b. Confirm factory testing and calibration of blower to the extent possible with the facilities available at the site of installation.
c. Verify all plant control system interfaces. Confirm all discrete signals and analog signals are calibrated and reporting accurately.
d. Confirm factory settings for pressure relief and pressure gages.
e. Perform field testing in the presence of the Owner and Engineer.

C. Make all necessary adjustments and corrective work as required.

D. Retesting: If any deficiencies are revealed during any test, such deficiencies shall be corrected, and the test shall be reconducted.

E. Submit a written report to Owner, with copy to Engineer, within seven working days of completion of testing. Report shall be in letter form showing operations performed and results obtained. Submit as specified in Division 01.

END OF SECTION 46 36 15

SECTION 46 41 41 – CARBON SYSTEM MIXERS

PART 1 - GENERAL

1.01 SUMMARY:

A. Section includes furnishing and placing into successful operation the following mixers:
   1. Mechanical Mixers:
      a. Top Mounted:
         (1) One total installed in the carbon slurry basin.

B. Furnish mechanical mixers complete with shafts, couplings, impellers, gear reducers, anchor bolts, motors, and all other parts and accessories specified or required for proper installation and operation.

C. Furnish a complete set of any special tools required for assembly, disassembly, or maintenance of mixers.

D. Provide service of Supplier's field service personnel during installation, testing, and initial operation of mixing equipment.

1.02 RELATED REQUIREMENTS:

A. Section 46 05 13 - Common Motor Requirements for Water and Wastewater Equipment.

1.03 REFERENCES:

A. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.

B. Name of Referenced Standard:
   1. American Bearing Manufacturer's Association (ABMA).
   2. American Gear Manufacturers Association (AGMA).
   3. American National Standards Institute (ANSI).
   4. American Society of Testing and Materials (ASTM).
   5. National Electrical Manufacturers Association (NEMA).
   6. NSF International (NSF).

1.04 SUBMITTALS:

A. Submittals shall include, but not be limited to, the following:
   1. General arrangement and detailed dimensional drawings showing:
      a. Mixers.
      b. Clearances required for installation, operation, and maintenance of mixers.
      c. Outline of assembled mixers and material components, including separate outlines of components as necessary.
      d. All required external connections to mixers.
   2. Mixer Support Design Data:
      a. Static and dynamic loadings for all operating conditions of mixers.
      b. Stress and moment data.
   3. Nameplate Data for all Mixer Motors:
      a. Manufacturer's name, type, and model.
      b. Rated horsepower.
      c. Service factor.
      d. Motor speed.
      e. Frequency, number of phases, and voltage.
   4. Data for all Mechanical Mixers.
      a. Mixer Supplier's name, type, and model.
      b. AGMA quality for all gears.

c. Bearings rated ABMA L10 life and calculations.
d. Rated pumping capacity.
e. Mixing volume turnover rate.
f. Impeller type.
g. Impeller diameter.
h. Impeller shaft diameter.
i. Impeller shaft speed.
j. Maximum impeller tip speed.
k. Design velocity gradient.
l. Drive horsepower rating.

5. Operations and Maintenance Manual.
6. Certificate of proper installation.

1.05 DELIVERY AND HANDLING:

A. Ship equipment as completely assembled as is possible.
B. If special precautions are required, prominently and legibly stencil instructions for such precautions on outside of equipment or its crating.

1.06 WARRANTY

A. Refer to Section 01 78 36 for warranty requirements.

PART 2 - PRODUCTS

2.01 ACCEPTABLE SUPPLIERS:

A. Mechanical Mixers:
1. Philadelphia Mixing Solutions / SPX Flow.
a. Model 3861
2. Engineer Approved Equal.

2.02 PERFORMANCE/DESIGN CRITERIA:

A. Mixer shall be designed for constant (single) speed operation.
B. Carbon Slurry Basin Mixer:
1. Service: Mixing of powdered activated carbon slurry.
2. Quantity: 1
3. Water Characteristics:
a. pH: Neutral.
b. Temperature: Ambient.
c. Design Slurry Concentration: 12% by weight.
d. Design Slurry Density: 52.9 lb/ft^3.
4. Basin Dimensions:
a. Horizontal area: 21’2” x 21’6”.
b. Total Depth: 23’0”.
c. Maximum Slurry Depth: 21’8”.
d. Minimum Slurry Depth: 2’10”.
(1) Mixer shall be designed to operate continuously at any slurry depth between the listed minimum and maximum levels.
5. Mixing Requirements:
a. Solids Characteristics:
(1) Concentration by weight: 10.0-20.0%

b. Type of suspension required: Uniform.
c. Maximum Allowable Horsepower: 60 HP
d. Maximum Motor Speed: 1800 RPM
e. Minimum number of mixer impellers: 2.
f. Minimum turnovers/min.: 2.0.

6. Shall be suitable for installation outdoors.
   a. Site outdoor temperature range: -13ºF to 109ºF.
7. Shall be designed to operate 24 hours per day.

2.03 MATERIALS:

A. Materials of Construction:
   1. Mechanical Mixers:
      a. Impeller and impeller shaft: 316 SS.
      b. Drive housing: Painted cast-iron or painted carbon steel.
   2. All wetted materials shall be NSF 61 certified.

2.04 MECHANICAL MIXERS:

A. General:
   1. Mixers shall be designed for continuous operation as indicated.
   2. Fully guard drive mechanisms or other moving parts in accordance with ANSI B15.1. Fabricate guards with steel or expanded metal, rigidly mounted and readily removed.
   3. Full-load operating noise levels of all mixers shall not exceed 85 dBA at 3 feet from any part of assembly.
   4. Mixer configuration shall include pedestal such that gearbox and motor can be removed while shaft remains in the tank.
   5. Contractor to provide mounting hardware including anchor bolts and fasteners.

B. Impellers and Impeller Shafts:
   1. Impeller shall be keyed to shaft, with at least one (1) key.
   2. All impellers shall be centered in the corresponding basin.
   3. Design of mixer shafts shall be in conformance of AGMA 260.01.
   4. Sections of impeller shaft shall be rigidly connected.
   5. Impeller pumping direction shall be counterclockwise.
   6. Impellers shall be statically balanced per ISO Grade 50, with impeller blades match-marked to hub location.

C. Drive Assembly:
   1. Unless specified otherwise, speed-reducing drives shall be gear type.
   2. Drive housing shall be provided with lifting lugs.
   3. Gear Reduction Unit:
      a. Gears for all right-angle drives shall be a combination of helical and spiral bevel conforming to AGMA 420.03 and 430.03.
      b. Gears for all other drives shall be helical and conform to AGMA 420.03.
      c. Gears shall be a minimum AGMA Quality 10 and conform to AGMA 390.03.
      d. The drive shall have a minimum service factor of 2.0 as measured at full motor nameplate.
      e. Thermal rating of the reducer shall exceed the design mechanical rating to eliminate the need for external cooling. External cooling devices are not allowed.
      f. The gearing shall be designed to withstand normal and shock loads that are transmitted to the gear drive from the agitator lower shaft and impeller assembly.

g. The gear reduction unit shall be specifically designed for mixing applications and protected from unbalanced hydraulic loadings.
h. Lubrication of the drive gear shall be splash type.
(1) Oil pumps will not be allowed.
(2) All lubricants shall be NSF-61 certified (supplied by Contractor).
(3) Provide a sight glass or dip stick to check level in oil reservoir.
(4) Provide seals which will positively prevent oil leakage around the shaft.

4. Bearings:
a. Locate above basin maximum water level.
b. Have a minimum L10 rating of 100,000 hours at maximum operating conditions and conform to ABMA No. 9 and No. 11.
c. Grease or oil lubricated, NSF-61 certified.
d. Provide and locate oil fill spout and visual oil level indication or dipstick in an easily accessible area.
e. Provide positive protection against oil or grease leakage into basin.
f. Bearings shall be manufactured in United States or Europe.

5. General maintenance shall not require the removal of the speed reducer housing from its foundation.

D. Horizontal-Mounted Motors:
1. Provide motors and accessories as specified in Section 46 05 13.
2. Motor shaft shall be connected to a gear-reducing drive input shaft through a flexible coupling.
3. Mixer configuration shall include pedestal such that gearbox and motor can be removed while shaft remains in the tank.

E. Flexible Couplings:
1. Be rated at not less than 140% of motor horsepower.
2. Shall prevent damage to drive assembly due to impeller shaft deflection or motor shaft misalignment.

2.05 FINISHES:

A. Shop Applications:
1. Stainless-steel surfaces shall not be painted.
2. Surface preparation and protective coating shall be Supplier's standard for the water/wastewater market.
3. Protective coatings must be suitable for outdoor installation.

B. Field Painting:
1. Supplier shall furnish Contractor with an adequate quantity of touch-up paint for field painting.

PART 3 - EXECUTION

3.01 ERECTION, INSTALLATION, APPLICATION:

A. Installation:
1. Installation, start-up, and testing of mixers shall conform to Supplier's recommendations.
2. Supplier's representative shall meet with Contractor and provide written guidelines (with a copy to Owner) and/or direct supervision to assure proper installation of mixers as specified below.

3. Contractor will provide mixer support anchors as needed for proper installation of equipment furnished per Supplier's recommendation. All anchor bolts, clips, etc., will be stainless steel.

B. Special Installation Instructions:
   1. Supplier shall furnish the Contractor a listing of any special installation instructions required for overall system installation.

C. Supplier's Field Services:
   1. The services of a Supplier's qualified technical representative (field personnel) shall be required at the Jobsite for installation verification and training of Owner's staff for proper operation of mixers and as required.
   2. The Supplier's field personnel shall demonstrate experience with installation, start-up, and operating of systems of comparable size, application, and complexity.
   3. In addition to the time necessary to complete the requirements established elsewhere in the Purchase Order, the field personnel shall be present at the Jobsite during the minimum times as follows:
      a. Minimum of two trips to the Jobsite, not to exceed a total of six eight-hour working days for services as listed paragraphs 3.01 and 3.02 with the specific provisions as follows.
      b. Training shall include a minimum of two working days for field training of Owner's Staff and shall generally include, but not be limited to, the following:
         (1) System operational theory and background.
         (2) Automatic control.
         (3) Manual control.
         (4) Required maintenance.
         (5) System troubleshooting.
      c. Contractor shall coordinate between Supplier's representative and Owner to schedule startup and training services.

3.02 FIELD QUALITY CONTROL:

A. Conduct in the presence of Owner and Contractor.

B. All testing and inspections shall be performed by the Supplier's representative per the Supplier's recommendations and requirements as specified.

C. Supplier's field representative shall check operation of mixers after installation and prior to start-up. Mixers shall be operated prior to filling basin with water as necessary to check impeller shaft alignment.

D. During start-up, Supplier's field representative shall, in the presence of the Owner and Contractor, operate each mixer, with basin filled to normal operating level, for at least one hour.
   1. Ascertain or appraise the ability of equipment to satisfactorily perform within Supplier's recommended tolerances.
   2. Check the following:
      a. Alignment.
      b. Vibration.
   3. Make adjustments as necessary to equipment to provide Supplier's recommended tolerances.

E. Supplier shall submit a written report within seven working days of completion of the field testing and inspections to Contractor covering all testing and inspection items and including any recommendations and corrections made.

1. Testing/inspection reports shall include full documentation of the test/inspection performed; including, but not limited to:
    a. Schematic of test performed.
    b. Testing/inspection equipment and instrument manual and calibration data.
    c. All data recorded during the test/inspection in the units listed within this specification and shown on the plans.
    d. Names of personnel present with an attendance sheet signed by the Owner, Contractor, or designee.

END OF SECTION 46 41 41