CONTRACT MANUAL

BUS ELECTRIFICATION IMPROVEMENTS

KITSAP TRANSIT
CHARLESTON BASE BUS CHARGERS PHASE 1

2/5/2021

I hereby certify that the Project Plans and Specifications in the Contract Documents were prepared by me or under my direct supervision and that I am a duly registered Engineer under the laws of the State of Washington.

_____
Project Engineer

February 2021

HDR ENGINEERING, INC.
700 SW Higgins Ave. Suite 200
Missoula, MT 59803
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Kitsap Transit

DC Fast Charger Installation

Construction Documents
Project Manual

HDR Project No. 10179662

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DIVISION 01

GENERAL REQUIREMENTS

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SECTION 01 11 00
SUMMARY OF WORK

PART 1 - GENERAL

1.1 SUMMARY

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1. Location and Description of Work.
2. Contracts for this Project.
3. Work by Others Under Owner's Control - Other Projects.
4. Work by Others Not Under Owner's Control.
5. Work by Owner.
6. Sequence and Progress of Work.
7. Contractor's Use of Site.
8. Easements and Rights-of-Way.
9. Partial Utilization by Owner.
10. Utility Owners.
11. Fences.

1.2 LOCATION AND DESCRIPTION OF WORK

A. The Work is located at the Charleston Bus Garage, in Bremerton, WA.

B. The Work to be performed under this Contract includes constructing the Work broadly described below, in accordance with the Contract Documents, with all related appurtenances. Work shown on the Drawings, or indicated in the Specifications, or indicated elsewhere in the Contract Documents is part of the Work, regardless of whether indicated below. The Work includes, but is not limited to, the following:
1. Concrete pavement removal, trenching, backfill, and replacement
2. Installing conduit and handholes, including spares for future installations, and electrical conductor for the charger installation.
    a. Conductor to be terminated under this contract at all points except for charger pads
    b. Conductor to be stubbed and taped 4 feet above charger pads for final termination by charger supplier under separate contract
3. Foundation and electrical installation of six (6) DC fast chargers for bus charging.
4. Modifications to existing bus charger feed to supply from the north and termination of existing feed to the existing charger.
5. Foundation and electrical installation of low voltage switchgear
6. Maintain space for future installation of Automatic Transfer Switch.
7. Bore beneath bus yard to allow PSE to install medium voltage conduit between existing circuit and proposed transformer location.
    a. Contractor to provide bore, bore pipe, and utility survey.
    b. Contractor to coordinate with Owner and PSE for bore termination locations and optimal routing and cable pulling.

C. Contracting Method: The Project will be constructed under a single prime construction contract.

D. Hazardous Environmental Conditions:
1. To the best of Owner's knowledge, information, and belief, the prior use of the Site included a bus garage and maintenance facility since 1950.
2. Should hazardous materials be discovered, the Owner retains the right to exercise a force account within this Contract to mitigate the hazard and avoid minimum interruptions.

E. Owner-Furnished Materials and Equipment:
1. Owner has pre-purchased the bus chargers and their final installation and commissioning. See Section 1.3 below for additional details.

2. Owner to provide utility connection via Puget Sound Energy at location shown on the drawing. PSE to install transformer and meter at location shown. See Section 1.4 below for additional details.

1.3 WORK BY OTHERS UNDER OWNER'S CONTROL - OTHER PROJECTS

A. Following installation of electrical equipment, conduit, conductor, and equipment pads at the charger, chargers to be installed under separate contract.
   1. Electrical Contractor (this Contract) to coordinate with charger manufacturer for the following items:
      a. Pad installation – Bolt pattern and conduit placement forms to be provided by charge manufacture prior to pouring pad. Template to be available for delivery upon NTP of this Contract
      b. Hand off – Electrical Contractor to walkthrough electrical installation with charger manufacture within 5 days prior to completion to hand off project to charger manufacturer and certify that electrical installation is complete and ready for charger installation

B. Owner has procured and purchased electric bus chargers. Bus charger installation to be completed under separate contract and not part of this Contract.
   a. Charger delivery scheduled for April 2021.
   b. Final completion scheduled for June 30, 2021

1.4 WORK BY OTHERS NOT UNDER OWNER'S CONTROL

A. Work by Utility Owners:
   1. Owner is aware of the work indicated below, to be performed at or adjacent to the Site, by utility owners (not under Owner's control).
   2. Electrical Contractor (this Contract) to coordinate with PSE for the following items:
      a. Transformer Vault
         1) PSE to provide transformer vault to electrical Contractor to install at location shown on Drawings.
      b. Bore Conduit
         1) Bore to be completed by electrical Contractor.
      c. Meter cabinet
         1) Electrical Contractor to provide EUSERC meter to be approved by PSE.
         2) Submittal will be sent from Contractor to Owner and then confirmed with PSE prior to purchase and installation.
         3) Electrical Contractor to install secondary conductor between transformer and meter and from meter throughout system.
         4) Contractor to coordinate completion with PSE for installation of PSE metering.
   3. Under separate contract, Owner to procure medium voltage electrical installation through the electric utility, Puget Sound Energy (PSE).
      a. PSE to provide installation of medium voltage electrical conductor to a new transformer located adjacent to the electrical meter installed under this Contract.
      b. PSE to install new junction box at south of site for termination of new MV conduit and conductor.
      c. This Contract to include coordination with PSE for final placement of the utility equipment prior to installing switchgear pad and conduit.
      d. Utility equipment installation scheduled for April 2021

1.5 SEQUENCE AND PROGRESS OF WORK

A. Sequencing:
   1. Incorporate sequencing of the Work into the Progress Schedule.
   2. All work under this Contract can begin with coordination, but without completion, of work performed under separate contract. Electrical Contractor shall coordinate placement of equipment with Owner, charger provider, and utility, but may begin excavation and installation following coordination.

3. Sequencing Requirements:
    a. Coordinate with Owner, charger provider, and utility for final equipment placement.
    b. Complete utility locate, including for bore, prior to excavation.
    c. Install all subsurface conduit and equipment pads.
    d. Final connections to utility equipment to be completed following installation of utility equipment.
    e. Final connections to switchgear and panels to be completed by Contractor following installation of equipment.
    f. Contractor to coordinate with ChargePoint installers for final inspection and commissioning.
    g. Final connections to chargers to be completed by charger installation contractor following installation of the chargers.

1.6 CONTRACTOR'S USE OF SITE

A. Contractors' use of the Site shall be confined to the areas shown on the Drawings.

B. Contractors shall share use of the Site with other contractors and others specified in Articles 1.3 1.4, and 1.5 of this Specifications section.

C. Move stored materials and equipment that interfere with operations of Owner, other contractors, and others performing work for Owner.

D. Limits on Contractor's use of the Site are:
    1. Locations shown on the drawing unless coordinated with Owner.
    2. Do not use the Site for operations other than those required for the Project.

E. Owner will occupy the Site jointly with Contractor during construction for performance of Owner's typical operations. Coordinate with Owner in all construction operations to minimize conflicts between Contractor and Owner's employees and others under Owner's control. If the Site is a treatment facility or other production facility, Owner will have Owner's suppliers for deliveries of chemicals and other items accessing the Site from time to time, possibly on a daily basis.

1.7 UTILITY OWNERS

A. Utilities known to Engineer who may have facilities (Underground Facilities or otherwise) in the vicinity of the Work are as follows:
    1. Puget Sound Energy
       Ryan Fish
       Project Manager
       Phone: 425-365-6940
    2. City of Bremerton – Water/Sewer
       Joe Keller
       Phone: 360-473-5270
    3. Cascade Natural Gas Corporation
       Shawn O-Neill
       Phone: 360-405-4225

1.8 TREE TRIMMING, CLEARING, AND TREE REMOVAL

A. Provide all required labor and equipment for trimming, clearing, and tree removal as follows:
    1. Tree trimming is required near the new electrical gear location, at the bus base entrance.
    2. Tree trimming may be required at the south of the bore location.

1.9 FENCES

A. All fences affected by the Work shall be maintained by the Contractor until completion of the Work. Fences disturbed by the Work shall be restored by Contractor to their original or better condition and to their original location unless otherwise indicated.

1.10 PERMITTING

A. The Owner has contacted the City of Bremerton and has completed the permitting for the following:
   1. Building Permit – Not required
   2. Stormwater Permit – Not required

B. The Contractor is responsible for obtaining the following permits:
   1. Electrical Permit – Washington Department of Labor and Industries

PART 2 - PRODUCTS - (NOT USED)

PART 3 - EXECUTION - (NOT USED)

END OF SECTION

SECTION 01 11 20
JOB CONDITIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Job conditions.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.

1.2 PROJECT CONDITIONS

A. Prior to installation of material, equipment and other work, verify with subcontractors, material or equipment manufacturers, and installers that the substrate or surface to which those materials attach is acceptable for installation of those materials or equipment. (Substrate is defined as building surfaces to which materials or equipment is attached to i.e., floors, walls, ceilings, etc.).

B. Correct unacceptable substrate until acceptable for installation of equipment or materials.

C. Maintaining Facility Operations:
   1. Facility is currently operating.
   2. Ensure construction activities do not interfere with Owner's operation of facility.
   3. Coordinate all planned modifications to facility operations with Owner including:
      a. Bus relocations for duct bank installation and material storage.
      b. Boring installation

PART 2 - PRODUCTS - (NOT USED)

PART 3 - EXECUTION - (NOT USED)

END OF SECTION

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SECTION 01 25 13
PRODUCT SUBSTITUTIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. The procedure for requesting the approval of substitution of a product that is not equivalent to a product which is specified by descriptive or performance criteria or defined by reference to one or more of the following:
      a. Name of manufacturer.
      b. Name of vendor.
      c. Trade name.
      d. Catalog number.
   2. Substitutions are not "or-equals."
   3. This Specification Section does not address substitutions for major equipment.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.

C. Request for Substitution - General:
   1. Base all bids on materials, equipment, and procedures specified.
   2. Certain types of equipment and kinds of material are described in specifications by means of references to names of manufacturers and vendors, trade names, or catalog numbers.
      a. When this method of specifying is used, it is not intended to exclude from consideration other products bearing other manufacturer's or vendor's names, trade names, or catalog numbers, provided said products are "or-equals," as determined by Engineer.
   3. Other types of equipment and kinds of material may be acceptable substitutions under the following conditions:
      a. Or-equals are unavailable due to strike, discontinued production of products meeting specified requirements, or other factors beyond control of Contractor; or,
      b. Contractor proposes a cost and/or time reduction incentive to the Owner.

1.2 QUALITY ASSURANCE

A. In making request for substitution or in using an approved product, Contractor represents they:
   1. Have investigated proposed product, and have determined that it is adequate or superior in all respects to that specified, and that it will perform function for which it is intended.
   2. Will provide same guarantee for substitute item as for product specified.
   3. Will coordinate installation of accepted substitution into Work, to include building modifications if necessary, making such changes as may be required for Work to be complete in all respects.
   4. Waives all claims for additional costs related to substitution which subsequently arise.

1.3 DEFINITIONS

A. Product: Manufactured material or equipment.

1.4 PROCEDURE FOR REQUESTING SUBSTITUTION AFTER AWARD OF CONTRACT

A. Substitution will only be considered under the conditions stated herein.

B. Written request through Contractor only.

C. Transmittal Mechanics:
   1. Follow the transmittal mechanics prescribed for Shop Drawings in Specification Section 01 33 00.

a. Product substitution will be treated in a manner similar to "deviations," as described in Specification Section 01 33 00.
b. List the letter describing the deviation and justifications on the transmittal form in the space provided under the column with the heading DESCRIPTION.
1) Include in the transmittal letter, either directly or as a clearly marked attachment, the items listed in Paragraph D below.

D. Transmittal Contents:
1. Product identification:
a. Manufacturer's name.
b. Telephone number and representative contact name.
c. Specification Section or Drawing reference of originally specified product, including discrete name or tag number assigned to original product in the Contract Documents.
2. Manufacturer's literature clearly marked to show compliance of proposed product with Contract Documents.
3. Itemized comparison of original and proposed product addressing product characteristics including but not necessarily limited to:
a. Size.
b. Composition or materials of construction.
c. Weight.
d. Electrical or mechanical requirements.
4. Product experience:
a. Location of past projects utilizing product.
b. Name and telephone number of persons associated with referenced projects knowledgeable concerning proposed product.
c. Available field data and reports associated with proposed product.
5. Data relating to changes in construction schedule.
6. Data relating to changes in cost.
7. Samples:
a. At request of Engineer.
b. Full size if requested by Engineer.
c. Held until substantial completion.
d. Engineer not responsible for loss or damage to samples.

1.5 APPROVAL OR REJECTION

A. Written approval or rejection of substitution given by the Engineer.

B. Engineer reserves the right to require proposed product to comply with color and pattern of specified product if necessary to secure design intent.

C. In the event the substitution is approved, the resulting cost and/or time reduction will be documented by Change Order in accordance with the General Conditions.

D. Substitution will be rejected if:
1. Submittal is not through the Contractor with his stamp of approval.
2. Request is not made in accordance with this Specification Section.
3. In the Engineer's opinion, acceptance will require substantial revision of the original design.
4. In the Engineer's opinion, substitution will not perform adequately the function consistent with the design intent.

E. Reimburse Owner for the cost of Engineer's evaluation whether or not substitution is approved.

PART 2 - PRODUCTS - (NOT USED)

PART 3 - EXECUTION - (NOT USED)

END OF SECTION

EXHIBIT A

Substitution Request Form

(One Item per each Form)

Project:	Date:	
Substitution Requestor:		
Contractor:		
Specification Section No:	Paragraph No. (i.e. 2.1.A.1.c):	Specified Item:
Proposed Substitution:		

Provide Product Data Sheets, Manufacturer's written installation instructions, drawings, diagrams, or any other information as an attached to this Form that will demonstrate the proposed substitution is an Approved Equal.

State differences between proposed substitutions and specified item. Differences include but are not limited to interrelationship with other items; materials, equipment, function, utility, life cycle costs, applied finished, appearances, and quality.

_____
_____
_____
_____

Document how the proposed substitution is compatible with or modifies other systems, parts, equipment or components of the Project and Work under the Contract

_____
_____
_____

Describe what effect the proposed substitution has on dimensions indicated on the Drawings and previously reviewed Shop Drawings?

_____
_____
_____

Describe what effect the proposed substitution has on the Construction Schedule and Contract Time.

_____
_____
_____

Describe what effect the proposed substitution has on the Contract Price. This includes all direct, indirect, impact and delay costs.

_____
_____
_____

Manufacturer's guarantees of the proposed and specified items are:

☐ Same ☐ Different (explain on attachment)

The undersigned state that the function, utility, life cycle costs, applied finishes, appearance and quality of the proposed substitution are equal or superior to those of the specified item.

For use by Project Representative:

☐ Accepted ☐ Accepted as Noted

☐ Not Accepted

_____ _____

(Date) *(Telephone)*:

_____

Project Representative's Signature

_____

(Contractor's Signature)

_____

(Contractor's Firm)

_____

(Firms Address)

_____

(Telephone)

Comments:

SECTION 01 32 16.02
CONSTRUCTION PROGRESS SCHEDULE (SMALL)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Specific requirements for the preparation, submittal, updating, and status reporting of the construction Progress Schedule.

B. Related Specification Sections include, but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.

C. Review of the CPM Schedule:
   1. In so far as the Contractor is solely responsible for its means and methods and the CPM schedule represents in part its means and methods, the review of the CPM schedules (preliminary, baseline, updates, revisions, etc.) is for compliance with the requirements as defined in the contract documents.
   2. The review of the CPM schedule is not intended to be complete or exhaustive or check every activity and its relation to the work.
   3. The Owner will provide comments on the CPM schedule compliance with those contract requirements and anomalies that might appear to the Owner.
   4. If the Contractor fails to include contract requirements (e.g. specified cure times, commissioning periods) in the CPM schedule, or the Owner fails to notify the Contractor of anomalies the Contractor is not relieved of the contract requirements.
   5. Acceptance of the CPM schedule does not imply that the Owner has approved or accepted the Contractor's means and methods or sequence for performing the work to construct the project.
   6. If the Contractor has questions or concerns about comments, the Contractor and Owner shall meet to resolve those issues prior to issuance of future updates or revisions.

1.2 DEFINITIONS

A. The following definitions shall apply to this Specification Section:
   1. Execution Of The Contract: The date the contract is signed by the last party, either the Owner or the Contractor.
   2. Working Days: Monday through Friday except holidays as directed by the Owner.
   3. Baseline Schedule: The initial detailed Progress Schedule prepared by the Contractor defining its plan for constructing the Project in accordance with the Contract Documents.
   4. Schedule Update: The initially accepted Baseline Schedule, or subsequently approved Revised Baseline Schedules, updated each month to reflect actual start and finish dates of each schedule activity and the remaining duration of activities that began during the period.
   5. Current Schedule: The current schedule is either the Baseline Schedule or Revised Baseline Schedule including and incorporating Schedule Updates.
   6. Revised Baseline Schedule: The initially accepted Baseline Schedule revised to reflect approved contract change orders and modifications.
   7. Recovery Schedule:
      a. A schedule indicating the Contractor's plan for recovering lost time.
      b. A recovery schedule will be requested when the Contractor is forecasting at least 10 working days or more delays in meeting a contract milestone or the contract completion date.
   8. Short Interval Schedule:
      a. Schedule prepared by the Contractor reflecting the work planned for the coming weeks.
      b. This is also known as a Look-Ahead Schedule.

1.3 SUBMITTALS

A. Baseline Schedule:
   1. Submittal and review:
      a. Submit within 30 days after Execution of the Contract or the effective date of the contract, whichever is earlier.
      b. The Owner shall review the baseline schedule and provide comments to the Contractor within 20 working days after receipt of the schedule.
      c. After receiving comments, the Contractor and Owner shall meet to review the comments within five working days.
      d. After the meeting, the Contractor will modify the schedule as agreed and resubmit the baseline schedule within 5 working days.
      e. After the Owner confirms that the Contractor has made the changes as agreed, the schedule will become the baseline schedule.
   2. Submittal package:
      a. CPM time-scaled network diagram:
         1) A printed logic diagram and PDF that include the following information:
            a) Unique activity number/identifier; numeric, alpha or combination of numeric/alpha.
            b) Activity description.
            c) Activity duration.
            d) Early start and early finish for each activity.
            e) Late start and late finish for each activity.
            f) Total float (TF) for each activity.
            g) Predecessor activities.
            h) Successor activities.
            i) Cost/budget to complete the work in the activity.
            j) Resources needed to complete the activity.
            k) Bar showing the early start and completion dates of each activity.
         2) The activities will be sorted by area, trades, and subcontractors as agreed on with the Owner.
         3) Print the CPM time-scaled network diagram on minimum sheet size of 11 IN x 17 IN.

B. Schedule Updates:
   1. Submittal and Review:
      a. Provide a Schedule Update on the 4th of each month after the Baseline Schedule is completed.
      b. The Owner shall provide comments to the Contractor on the Schedule Update.
      c. Incorporate the Owner comments into the next Schedule Update.
   2. CPM time-scaled network diagram as described for the Baseline Schedule:
      a. Do not change the description of an activity number.
         1) Any activity added to the schedule shall have a new unique activity number and description.
         2) If activities are deleted, the deleted activity number(s) will not be used again.

C. Recovery Schedule:
   1. When the activities on the critical path or the completion milestones appear to be 15 working days beyond the contract time, the Owner may request and provide a Recovery Schedule demonstrating how the Contractor will recover the lost time so that the Work will be completed within the Contract Time.
   2. Provide the Recovery schedule within 10 working days after requested by the Owner.
   3. Activities will be added or the durations modified to reflect the changes to the work.
   4. The Owner will review and provide comments to the Contractor on the Recovery Schedule within five working days.
   5. Incorporate the Owner comments into the Recovery Schedule.
   6. After acceptance by the Owner, the Recovery Schedule use for future Schedule Updates.

7. CPM time-scaled network diagram as described for the Baseline Schedule:
    a. Do not change the description of an activity number.
        1) Any activity added to the schedule shall have a new activity number and description.
        2) If activities are deleted, the deleted activity number(s) will not be used again.
8. Provide a narrative with an explanation of the changes in logic and/or activity durations.

D. Short Interval Schedule:
1. Provide a three-weekschedule each week during the Contract Time. This schedule can be reviewed at each progress meeting.
    a. Provide an accurate representation of the work performed the previous week and work planned for the current week and subsequent two weeks.
2. Provide in a tabular format with bars or other graphic representing work duration.
    a. Reference activity ID numbers on the Baseline, Revised Baseline, or Updated Schedule, which ever is being currently used.
    b. Note by color, highlight or underscore all activities on the critical path.
3. Identify inspection hold points including special inspections needed before the Contractor can move forward with the work.
4. Identify the day materials provided by the Owner or others needed on site.
5. Identify utility tie-ins and traffic changes including road and/or lane closures.

1.4 GENERAL REQUIREMENTS

A. Prepare and submit construction progress schedules as specified herein.
1. Develop and maintain Baseline, Updates and Recovery schedules using Microsoft Project or equal as approved by the Owner.
2. Include the following information:
    a. Construction start dates (Award date, Notice(s) to Proceed date).
    b. Procurement activities.
    c. Preparation of key submittals for materials and equipment.
    d. Engineers review and approval of key submittals.
    e. Material and equipment fabrication lead times.
    f. Material and equipment deliveries for Contractor, Owner and third parties.
    g. Water curing of concrete after placement for all structures.
    h. Shutdowns.
    i. Utility tie-ins.
    j. Plant tie-ins.
    k. Traffic changes and closures.
    l. Inspections and hold points.
    m. Start-up of equipment.
    n. Testing of equipment and systems.
    o. Training
    p. Commissioning.
    q. Contract milestones:
        1) Intermediate milestones.
        2) Substantial Completion Date.
        3) Physical Completion Date.
3. The following CPM schedule outputs will be rejected without further review:
    a. Schedules indicating the start of the critical path at a date point or activity beyond the date of Notice to Proceed, or schedules indicating a discontinuous critical path from Notice to Proceed to Contract completion.
    b. Schedules defining critical activities as those on a path or paths having some minimum value of float.
    c. Schedules with multiple critical paths.
    d. Schedules indicating a completion date beyond the contractual completion date.

B. The number of activities shall be sufficient to assure adequate planning of the project, to permit monitoring and evaluation of progress, and to do an analysis of time impacts.
   1. Work activities shall not exceed durations of 10 days or two weeks.
      a. Procurement and fabrication activity durations may exceed 10 days or two weeks.
   2. Schedule activities shall include the following:
      a. A clear and legible description.
      b. At least one predecessor and one successor activity, except for project start and finish milestones.

C. Early Completion Schedule:
   1. Contractor may show early completion time on any schedule provided that the requirements of the contract are met.
   2. Contractor may increase early completion time by improving production, reallocating resources to be more efficient, performing sequential activities concurrently or by completing activities earlier than planned.
   3. Any time between the Contractor's early completion and the Contract Time will be considered float.

D. Plan working durations to incorporate the effects of normal weather impacts.

E. Float:
   1. The project owns the float, therefore neither the Owner nor the Contractor has exclusive use of the float; the float can used by either party.
   2. Once float is used, liability for delay of the project completion date rests with the party actually causing delay to the project completion date.

PART 2 - PRODUCTS - (NOT USED)

PART 3 - EXECUTION - (NOT USED)

END OF SECTION

SECTION 01 33 00
SUBMITTALS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Mechanics and administration of the submittal process for:
      a. Shop Drawings.
      b. Samples.
      c. Informational submittals.
   2. General content requirements for Shop Drawings.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Construction Progress Schedule submittal requirements are specified in Specification Section 01 32 16.
   4. Operations and Maintenance Manual submittal requirements are specified in Specification Section 01 33 04.
   5. Technical Specification Sections identifying required submittals.

1.2 DEFINITIONS

A. Action Submittals:
   1. Action Submittals require an explicit, written approval or other appropriate action by Engineer before Contractor may release the associated item(s) for raw materials procurement, fabrication, production, and shipment.
   2. Unless otherwise indicated in the Contract Documents, Action Submittals include the following:
      a. Shop Drawings.
      b. Product data.
      c. Samples.
      d. Testing plans for quality control activities required by the Contract Documents.
      e. Delegated Designs: Design drawings, design specifications, calculations, reports, and other instruments of service sealed and signed by design professional retained by Contractor, Subcontractor, or Supplier for a portion of the completed Work as part of the completed Project. Engineer's approval or other appropriate action on such delegated design Submittals will be only for the limited purposes set forth in the General Conditions.

B. Informational Submittals:
   1. Informational Submittals are Submittals, other than Action Submittals, required by the Contract Documents. Explicit response from Engineer is not required when such Submittal is acceptable and Engineer's acceptance thereof will be indicated in the Engineer's Submittals log. When Informational Submittal does not indicate full compliance with the Contract Documents, Engineer will indicate the non-compliance in a written response to Contractor.
   2. Representative types of informational submittal items include but are not limited to:
      a. Installed equipment and systems performance test reports.
      b. Manufacturer's installation certification letters.
      c. Instrumentation and control commissioning reports.
      d. Warranties.
      e. Service agreements.
      f. Construction photographs.

g. Work plans.
h. Shop Drawings, product data, Samples, and testing plans, submitted as a requirement of for delegated designs, bearing the Submittal approval stamp of associated design professional retained by Contractor, Subcontractor, or Supplier.

3. For-Information-Only submittals upon which the Engineer is not expected to conduct review or take responsive action may be so identified in the Contract Documents.

1.3 SUBMITTAL SCHEDULE

A. Schedule of Shop Drawings:
1. Submitted and approved within 20 days of receipt of Notice to Proceed.
2. Account for multiple transmittals under any specification section where partial submittals will be transmitted.

B. Shop Drawings: Submittal and approval prior to 30 PCT completion of project.

C. Informational Submittals:
1. Reports and installation certifications submitted within seven days of conducting testing, installation, or examination.
2. Submittals showing compliance with required qualifications submitted 20 days prior to any work beginning using the subject qualifications.

1.4 PREPARATION OF SUBMITTALS

A. General:
1. All submittals and all pages of all copies of a submittal shall be completely legible.
2. Submittals which, in the Engineer's sole opinion, are illegible will be returned without review.
3. Minimize extraneous information for equipment and products not relevant to the submittal.
4. Contractors or vendors written comments on the submittal drawings shall be in green

B. Shop Drawings, Product Data, and Samples:
1. Scope of any submittal and letter of transmittal:
a. Limited to one Specification Section.
b. Submittals with more than one Specification section included will be rejected.
c. Do not submit under any Specification Section entitled (in part) "Basic Requirements" unless the product or material submitted is specified, in total, in a "Basic Requirements" Specification Section.
2. Numbering letter of transmittal:
a. Include as prefix the Specification Section number followed by a series number, "-xx", beginning with "01" and increasing sequentially with each additional transmittal for that Specification Section.
b. If more than one submittal under any Specification Section, assign consecutive series numbers to subsequent transmittal letters.
3. Describing transmittal contents:
a. Provide listing of each component or item in submittal capable of receiving an independent review action.
b. Identify for each item:
1) Manufacturer and Manufacturer's Drawing or data number.
2) Contract Document tag number(s).
3) Unique page numbers for each page of each separate item.
c. When submitting "or-equal" items that are not the products of named manufacturers, include the words "or-equal" in the item description.
4. Contractor certification of review and approval:
a. Contractor's review and approval certification stamp shall be applied either to the letter of transmittal or a separate sheet preceding each independent item in the submittal.
1) Stamp may be either a wet ink stamp or electronically embedded.
2) Clearly identify the person who reviewed the submittal and the date it was reviewed.

3) Shop Drawing submittal stamp shall read "(Contractor's Name) has satisfied Contractor's obligations under the Contract Documents with respect to Contractor's review and approval as stipulated in the General Conditions."

b. Submittals containing multiple independent items shall be prepared with each item listed on the letter of transmittal or on an index sheet for all items listing the discrete page numbers for each page of each item, which shall be stamped with the Contractor's review and approval stamp.
   1) Each independent item shall have a cover sheet with the transmittal number and item number recorded.
      a) Provide clear space of 3 IN SQ for Engineer stamping.
   2) Individual pages or sheets of independent items shall be numbered in a manner that permits the entire contents of a particular item to be readily recognized and associated with Contractor's certification.

5. Resubmittals:
   a. Number with original Specification Section and series number with a suffix letter starting with "A" on a (new) duplicate transmittal form.
   b. Do not increase the scope of any prior transmittal.
   c. Provide cover letter indicating how each "B", "C", or "D" Action from previous submittal was addressed and where the correction is found in the resubmittal.
   d. Account for all components of prior transmittal.
      1) If items in prior transmittal received "A" or "B" Action code, list them and indicate "A" or "B" as appropriate.
         a) Do not include submittal information for items listed with prior "A" or "B" Action in resubmittal.
      2) Indicate "Outstanding-To Be Resubmitted At a Later Date" for any prior "C" or "D" Action item not included in resubmittal.
         a) Obtain Engineer's approval to exclude items.
6. Do not use red color for marks on transmittals.
   a. Duplicate all marks on all copies transmitted, and ensure marks are photocopy reproducible.
   b. Engineer will use red marks or enclose marks in a cloud.
7. Transmittal contents:
   a. Coordinate and identify Shop Drawing contents so that all items can be easily verified by the Engineer.
   b. Provide submittal information or marks defining specific equipment or materials utilized on the Project.
      1) Generalized product information, not clearly defining specific equipment or materials to be provided, will be rejected.
   c. Identify equipment or material project use, tag number, Drawing detail reference, weight, and other Project specific information.
   d. Provide sufficient information together with technical cuts and technical data to allow an evaluation to be made to determine that the item submitted is in compliance with the Contract Documents.
   e. Do not modify the manufacturer's documentation or data except as specified herein.
   f. Submit items such as equipment brochures, cuts of fixtures, product data sheets or catalog sheets not exceeding 11 x 17 IN pages.
      1) Indicate exact item or model and all options proposed by arrow and leader.
   g. When a Shop Drawing submittal is called for in any Specification Section, include as appropriate, scaled details, sizes, dimensions, performance characteristics, capacities, test data, anchoring details, installation instructions, storage and handling instructions, color charts, layout Drawings, rough-in diagrams, wiring diagrams, controls, weights and other pertinent data in addition to information specifically stipulated in the Specification Section.
      1) Arrange data and performance information in format similar to that provided in Contract Documents.

2) Provide, at minimum, the detail specified in the Contract Documents.

h. If proposed equipment or materials deviate from the Contract Drawings or Specifications in any way, clearly note the deviation and justify the said deviation in detail in a separate letter immediately following transmittal sheet. Any deviation from plans or specifications not depicted in the submittal or included but not clearly noted by the Contractor may not have been reviewed. Review by the Engineer shall not serve to relieve the Contractor of the contractual responsibility for any error or deviation from contract requirements.

8. Samples:
   a. Identification:
      1) Identify sample as to transmittal number, manufacturer, item, use, type, project designation, tag number, Specification Section or Drawing detail reference, color, range, texture, finish and other pertinent data.
      2) If identifying information cannot be marked directly on sample without defacing or adversely altering samples, provide a durable tag with identifying information securely attached to the sample.
   b. Include application specific brochures, and installation instructions.
   c. Provide Contractor's review and approval certification stamp or Contractor's Submittal Certification form as indication of Contractor's checking and verification of dimensions and coordination with interrelated work.
   d. Resubmit revised samples of rejected items.

C. Informational Submittals:
   1. Prepare in the format and detail specified in Specification requiring the informational submittal.

1.5 TRANSMITTAL OF SUBMITTALS

A. Shop Drawings and Samples:
   1. Transmit all submittals to:

      Kitsap Transit
      60 Washington Avenue, Suite 200
      Bremerton, WA 98337
      Attn: Jeff Davidson
      Email: Jeff Da@KitsapTransit.com

   2. Utilize two copies of attached Exhibit A to transmit all Shop Drawings and samples.
   3. All submittals must be from Contractor.
      a. Submittals will not be received from or returned to subcontractors.

B. Informational Submittals:
   1. Transmit under Contractor's standard letter of transmittal or letterhead.
   2. Submit in triplicate or as specified in individual Specification Section.
   3. Transmit to:

      Kitsap Transit
      60 Washington Avenue, Suite 200
      Bremerton, WA 98337
      Attn: Jeff Davidson
      Email: Jeff Da@KitsapTransit.com

C. Electronic Transmission of Submittals:
   1. Transmittals shall be made electronically.
      a. Use email.
      b. Protocols and processes will be determined at the Pre-Construction Conference.
   2. Provide documents in Adobe Acrobat Portable Document Format (PDF), latest version.

3. Do not password protect or lock the PDF document.
4. Drawings or other graphics must be converted to PDF file format from the original drawing file format and made part of the PDF document.
    a. Scanning of drawings is to be used only where actual file conversion is not possible and drawings must be scanned at a resolution of 300 DPI or greater.
    b. Required signatures may be applied prior to scanning for transmittal.
5. Electronic drawings shall be formatted to be at full-scale (or half-scale when printed to 11x17).
    a. Do not reduce drawings by more than 50 PCT in size.
    b. Reduced drawings shall be clearly marked "HALF-SIZE" and shall scale accurately at that size.
6. Rotate sheets that are normally viewed in landscape mode so that when the PDF file is opened the sheet is in the appropriate position for viewing.
7. Create bookmarks in the bookmarks panel for the cover, the Table of Contents, and each major section of the document.
8. Using Adobe Acrobat Standard or Adobe Acrobat Professional, set the PDF document properties, initial view as follows:
    a. Select File →Properties→Initial View.
    b. Select the Navigation tab: Bookmarks Panel and Page.
    c. Select the Page layout: Single Page.
    d. Select the Magnification: Fit Page.
    e. Select Open to page: 1.
    f. Set the file to open to the cover page with bookmarks to the left, and the first bookmark linked to the cover page.
9. Set the PDF file "Fast Web View" option to open the first several pages of the document while the rest of the document continues to load.
    a. To do this:
        1) Select Edit→Preferences→ Documents→Save Settings.
        2) Check the Save As optimizes for Fast Web View box.
10. File naming conventions:
    a. File names shall use the convention (XXXXXX-YY-Z.PDF) where XXXXXX is the Specification Section number, YY is the Shop Drawing Root number and Z is an ID number used to designate the associated volume.
11. Labeling:
    a. As a minimum, include the following labeling on all electronic media:
        1) Project Name.
        2) Equipment Name and Project Tag Number.
        3) Project Specification Section.
        4) Manufacturer Name.
        5) Vendor Name.
12. Binding:
    a. Include labeled electronic media in a protective case.
        1) Bind protective case in three-ring binder, inserted at the front of the Final paper copy submittal.
        2) Protective case(s) to have means for securing electronic media to prevent loss (e.g., zip case, flap and strap, or equivalent).

1.6 ENGINEER'S REVIEW ACTION

A. Shop Drawings and Samples:
1. Items within transmittals will be reviewed for overall design intent and will receive one of the following actions:
    a. A - FURNISH AS SUBMITTED.
    b. B - FURNISH AS NOTED (BY ENGINEER).
    c. C - REVISE AND RESUBMIT.
    d. D - REJECTED.

e. E - ENGINEER'S REVIEW NOT REQUIRED.

2. Submittals received will be initially reviewed to ascertain inclusion of Contractor's approval stamp.
   a. Submittals not stamped by the Contractor or stamped with a stamp containing language other than that specified herein will not be reviewed for technical content and will be returned rejected.
3. In relying on the representation on the Contractor's review and approval stamp, Owner and Engineer reserve the right to review and process poorly organized and poorly described submittals as follows:
   a. Submittals transmitted with a description identifying a single item and found to contain multiple independent items:
      1) Review and approval will be limited to the single item described on the transmittal letter.
      2) Other items identified in the submittal will:
         a) Not be logged as received by the Engineer.
         b) Be removed from the submittal package and returned without review and comment to the Contractor for coordination, description and stamping.
         c) Be submitted by the Contractor as a new series number, not as a re-submittal number.
   b. Engineer, at Engineer's discretion, may revise the transmittal letter item list and descriptions, and conduct review.
      1) Unless Contractor notifies Engineer in writing that the Engineer's revision of the transmittal letter item list and descriptions was in error, Contractor's review and approval stamp will be deemed to have applied to the entire contents of the submittal package.
4. Submittals returned with Action "A" or "B" are considered ready for fabrication and installation.
   a. If for any reason a submittal that has an "A" or "B" Action is resubmitted, it must be accompanied by a letter defining the changes that have been made and the reason for the resubmittal.
   b. Destroy or conspicuously mark "SUPERSEDED" all documents having previously received "A" or "B" Action that are superseded by a resubmittal.
5. Submittals with Action "A" or "B" combined with Action "C" (Revise and Resubmit) or "D" (Rejected) will be individually analyzed giving consideration as follows:
   a. The portion of the submittal given "C" or "D" will not be distributed (unless previously agreed to otherwise at the Preconstruction Conference).
      1) One copy or the one transparency of the "C" or "D" Drawings will be marked up and returned to the Contractor.
         a) Correct and resubmit items so marked.
   b. Items marked "A" or "B" will be fully distributed.
   c. If a portion of the items or system proposed are acceptable, however, the major part of the individual Drawings or documents are incomplete or require revision, the entire submittal may be given "C" or "D" Action.
      1) This is at the sole discretion of the Engineer.
      2) In this case, some Drawings may contain relatively few or no comments or the statement, "Resubmit to maintain a complete package."
      3) Distribution to the Owner and field will not be made (unless previously agreed to otherwise).
6. Failure to include any specific information specified under the submittal paragraphs of the Specifications will result in the submittal being returned to the Contractor with "C" or "D" Action.
7. Calculations required in individual Specification Sections will be received for information purposes only, as evidence calculations have been stamped by the professional as defined in the specifications and for limited purpose of checking conformance with given performance and design criteria. The Engineer is not responsible for checking the accuracy of the

calculations and the calculations will be returned stamped "E. Engineer's Review Not Required" to acknowledge receipt.

8. Furnish required submittals with sufficient information and accuracy to obtain required approval of an item with no more than three submittals. Engineer will record Engineer's time for reviewing a fourth or subsequent submittal of a Shop Drawings, sample, or other item requiring approval, and Contractor shall be responsible for Engineer's charges to Owner for such time. Owner may impose a set-off against payments due to Contractor to secure reimbursement for such charges.
9. Transmittals of submittals which the Engineer considers as "Not Required" submittal information, which is supplemental to but not essential to prior submitted information, or items of information in a transmittal which have been reviewed and received "A" or "B" action in a prior submittal, will be returned with action "E. Engineer's Review Not Required."
10. Samples may be retained for comparison purposes.
    a. Remove samples when directed.
    b. Include in bid all costs of furnishing and removing samples.
11. Approved samples submitted or constructed, constitute criteria for judging completed work.
    a. Finished work or items not equal to samples will be rejected.

PART 2 - PRODUCTS - (NOT USED)

PART 3 - EXECUTION - (NOT USED)

END OF SECTION

EXHIBIT A

Shop Drawing Transmittal No.

_____-_____

(Spec Section) (Series)

Project Name:		Date Received:	
Project Owner:		Checked By:	
Contractor:	HDR Engineering, Inc.	Log Page:	
Address:	Address:	HDR No.:	
		Spec Section:	
		Drawing/Detail No.:	
Attn:	Attn:	1st. Sub	ReSub.
Date Transmitted:	Previous Transmittal Date:		

Item No.	No. Copies	Description	Manufacturer	Mfr/Vendor Dwg or Data No.	Action Taken*

Remarks:

* The Action designated above is in accordance with the following legend:

A - Furnish as Submitted

B - Furnish as Noted

C - Revise and Submit
1. Not enough information for review.
2. No reproducibles submitted.
3. Copies illegible.
4. Not enough copies submitted.
5. Wrong sequence number.
6. Wrong resubmittal number.
7. Wrong spec. section.
8. Wrong form used.
9. See comments.

D - Rejected

E - Engineer's review not required
1. Submittal not required.
2. Supplemental Information. Submittal retained for informational purposes only.
3. Information reviewed and approved on prior submittal.
4. See comments.

Engineer's review and approval will be only to determine if the items covered by the submittals will, after installation or incorporation in the Work, conform to the 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. Any deviation from plans or specifications not depicted in the submittal or included but not clearly noted by the Contractor may not have been reviewed. Review by the Engineer shall not serve to relieve the Contractor of the contractual responsibility for any error or deviation from contract requirements.

Comments:

By Date

Distribution: Contractor | File | Field | Owner | Other

EXHIBIT AA

Contractor's Submittal Certification

Shop Drawing Transmittal No.: _____

Contract/Project Name: _____

_____

Company Name: _____

has

1. reviewed and coordinated this Shop Drawing or Sample with other Shop Drawings and Samples and with the requirements of the Work and the Contract Documents;

2. determined and verified all field measurements, quantities, dimensions, specified performance and design criteria, installation requirements, materials, catalog numbers, and similar information with respect thereto;

3. determined and verified the suitability of all materials offered with respect to the indicated application, fabrication, shipping, handling, storage, assembly, and installation pertaining to the performance of the Work; and

4. determined and verified all information relative to Contractor's responsibilities for means, methods, techniques, sequences, and procedures of construction, and safety precautions and programs incident thereto.

☐ This Submittal **does not** contain any variations from the requirements of the Contract Documents.

☐ This Submittal **does** contain variations from the requirements of the Contract Documents. A separate description of said variations and a justification for them is provided in an attachment hereto identified as:

"Shop Drawing Transmittal No. _____Variation and Justification Documentation"

Insert picture file or electronic signature of Authorized Representative

_____ _____

Authorized Representative Date

SECTION 01 33 04
OPERATION AND MAINTENANCE MANUALS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Administration of the submittal process for Operation and Maintenance Manuals.
   2. Content requirements for Operation and Maintenance Manuals.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. General submittal requirements are specified in Specification Section 01 33 00 - Submittals.
   4. Technical Specification Sections identifying required Operation and Maintenance Manual submittals.

1.2 DEFINITIONS

A. Equipment Operation and Maintenance Manuals:
   1. Contain the technical information required for proper installation, operation and maintenance of process, electrical and mechanical equipment and systems.

B. Building Materials and Finishes Operation and Maintenance Manuals:
   1. Contain the information required for proper installation and maintenance of building materials and finishes.

1.3 SUBMITTALS

A. List of all the Operation and Maintenance Manuals required by the Contract as identified in the Technical Specification Sections. These may be referred to as "Operation and Maintenance Data" submittals.

B. Operation and Maintenance Manuals:
   1. Draft and final electronic copies.
   2. Final paper copies: One.

1.4 SUBMITTAL SCHEDULE

A. List of Required Operation and Maintenance Manuals:
   1. Submit list with Specification Section number and title within 90 days after Notice to Proceed.

B. Draft Operation and Maintenance Manuals:
   1. Submit approvable draft manuals in electronic format (PDF) within 30 days following approval of the respective Shop Drawing.
      a. Include placeholders or fly sheet pages where information is not final or is missing from the draft manual.
   2. All Draft Operation and Maintenance Manuals shall be received by no later than 50 PCT project completion.

C. Final Operation and Maintenance Manuals:
   1. Final approval of Operation and Maintenance Manuals in electronic format (PDF) must be obtained 45 days prior to equipment start-up.

2. Provide paper copies and Electronic Documents (in portable document format, PDF files) by Electronic Means of approved final Operation and Maintenance Manuals in electronic format (PDF), a minimum of 30 days prior to equipment start-up.
3. Issue addenda to Final Approved Operation and Maintenance Manual to include:
    a. Equipment data that requires collection after start-up, for example but not limited to HVAC balancing reports, electrical switchgear, automatic transfer switch and circuit breaker settings.
    b. Equipment field testing data.
    c. Equipment start-up reports.

1.5 PREPARATION OF SUBMITTALS

A. General:
1. All pages of the Operation and Maintenance Manual submittal shall be legible.
    a. Submittals which, in the Engineer's sole opinion, are illegible will be rejected without review.
2. Identify each equipment item in a manner consistent with names and identification numbers used in the Contract Documents, not the manufacturer's catalog numbers.
3. Neatly type any data not furnished in printed form.
4. Operation and Maintenance Manuals are provided for Owner's use, to be reproduced and distributed as training and reference materials within Owner's organization.
    a. This requirement is:
        1) Applicable to both paper copy and electronic files.
        2) Applicable to materials containing copyright notice as well as those with no copyright notice.
5. Notify supplier and/or manufacturer of the intended use of Operations and Maintenance Manuals provided under the Contract.

B. Operation and Maintenance Manual Format and Delivery:
1. Draft electronic submittals:
    a. Provide manual in Adobe Acrobat Portable Document Format (PDF), latest version.
    b. Create one (1) PDF file for each equipment Operation and Maintenance Manual.
    c. Do not password protect or lock the PDF document.
    d. Scanned images of paper documents are not acceptable. Create the Operation and Maintenance Manual PDF file from the original source document.
    e. Drawings or other graphics must be converted to PDF file format from the original drawing file format and made part of the PDF document.
    f. Scanning of drawings is to be used only where actual file conversion is not possible and drawings must be scanned at a resolution of 300 DPI or greater.
    g. Rotate sheets that are normally viewed in landscape mode so that when the PDF file is opened the sheet is in the appropriate position for viewing.
    h. Create bookmarks in the bookmarks panel for the Operation and Maintenance Manual cover, the Table of Contents and each major section of the Table of Contents.
    i. Using Adobe Acrobat Standard or Adobe Acrobat Professional, set the PDF document properties, initial view as follows:
        1) Select File →Properties→Initial View.
        2) Select the Navigation tab: Bookmarks Panel and Page.
        3) Select the Page layout: Single Page Continuous.
        4) Select the Magnification: Fit Page.
        5) Select Open to page: 1.
        6) Set the file to open to the cover page of the manual with bookmarks to the left, and the first bookmark linked to the cover page.
        7) Window Options: Check the "Resize window to initial page" box.
    j. Set the PDF file "Fast Web View" option to open the first several pages of the document while the rest of the document continues to load.
        1) To do this:
            a) Select Edit→Preferences→ Documents→Save Settings.

b) Check the "Save As optimizes for Fast Web View" box.

k. PDF file naming convention:
   1) Use the Specification Section number, the manufacturer's name and the equipment description, separated by underscores.
   2) Example: 46 51 21_Sanitaire_Coarse_Bubble_Diffusers.pdf.
   3) Do not put spaces in the file name.

2. Final electronic submittals:
   a. Submit two copies as Electronic Documents (in portable document format, PDF files) by Electronic Means (one copy per electronic media), each secured in a protective case.
   b. Labeling:
      1) Provide the following printed labeling on all electronic media:
         a) Project name.
         b) Specification Section.
         c) Equipment names and summary of tag(s) covered.
         d) Manufacturer name.
         e) Date (month, year).
   c. Binding:
      1) Include labeled electronic media in a protective case.
         a) Bind protective case in three-ring binder, inserted at the front of the Final paper copy submittal.
         b) Protective case(s) to have means for securing electronic media to prevent loss (e.g., zip case, flap and strap, or equivalent).
3. Final paper copy submittals:
   a. Quantity: Provide two copies.
   b. Paper: 8.5 x 11 IN or 11 x 17 IN bright white, 20 LB paper with standard three-hole punching.
   c. 3-Ring Binder:
      1) Provide D-ring binder with clear vinyl sleeves (i.e. view binder) on front and spine.
      2) Insert binder title sheet with the following information under the front and spine sleeves:
         a) Project name.
         b) Specification Section.
         c) Equipment names and summary of tag(s) covered.
         d) Manufacturer name.
         e) Date (month, year).
      3) Provide plastic sheet lifters prior to first page and following last page.
   d. Drawings:
      1) Provide all drawings at 11 x 17 IN size, triple folded and three-hole punched for insertion into manual.
      2) Where reduction is not practical to ensure readability, fold larger drawings separately and place in three-hole punched vinyl envelopes inserted into the binder.
      3) Identify vinyl envelopes with drawing numbers.
   e. Use plastic coated dividers to tab each section of each manual in accordance with the Table of Contents.

C. Equipment Operation and Maintenance Manual Content:
   1. Provide a cover page as the first page of each manual with the following information:
      a. Manufacturer(s) Name and Contact Information.
      b. Vendor's Name and Contact Information.
      c. Date (month, year).
      d. Project Owner and Project Name.
      e. Specification Section.
      f. Project Equipment Tag Numbers.
      g. Model Numbers.
      h. Engineer's Name.
      i. Contractor's Name.

2. Provide a Table of Contents for each manual.
3. Provide Equipment Record sheets as follows:
    a. Printed copies of the Equipment Record (Exhibits B1, B2 and B3), as the first tab following the Table of Contents.
        1) For Instrumentation and Control equipment, International Society of Automation (ISA) Data Sheets will be acceptable in lieu of the Equipment Record sheets.
    b. Exhibits B1-B3 are available as Fillable PDF Form documents from the Engineer.
    c. Each section of the Equipment Record must be completed in detail; simply referencing the related equipment Operation and Maintenance Manual sections for nameplate, maintenance, spare parts or lubricant information is not acceptable.
    d. For equipment involving separate components (for example, a motor and gearbox), a fully completed Equipment Record is required for each component.
    e. Submittals that do not include the Equipment Record(s) will be rejected without further content review.
4. Provide a printed copy of the Manufacturer's Field Services report as required by Specification Section 01 75 00 following the Equipment Record sheets.
5. Provide the following detailed information, as applicable:
    a. Use equipment tag numbers from the Contract Documents to identify equipment and system components.
    b. Equipment function, normal and limiting operating characteristics.
    c. Instructions for assembly, disassembly, installation, alignment, adjustment, and inspection.
    d. Operating instructions for start-up, normal operation, control, shutdown, and emergency conditions.
    e. Maintenance instructions, including lubrication instructions if applicable
    f. Troubleshooting guide.
    g. Mark each sheet to clearly identify specific products and component parts and data applicable to the installation for the Project; delete or cross out information that does not specifically apply to the Project.
    h. Parts lists:
        1) A parts list and identification number of each component part of the equipment.
        2) Exploded view or plan and section views of the equipment with a detailed parts callout matching the parts list.
        3) A list of recommended spare parts.
        4) List of spare parts provided as specified in the associated Specification Section.
        5) A list of any special storage precautions which may be required for all spare parts.
    i. General arrangement, cross-section, and assembly drawings.
    j. Electrical diagrams, including elementary diagrams, wiring diagrams, connection diagrams, and interconnection diagrams.
    k. Factory and field test data and performance curves (if applicable).
    l. As-constructed fabrication or layout drawings and wiring diagrams.
    m. Copy of the equipment manufacturer's warranty meeting the requirements of the Contract.
    n. Copy of any service contracts provided for the specific piece of equipment as part of the Contract.
6. Additional information as required in the associated equipment or system Specification Section.
7. Include in Submittal the final, configured control setpoints and similar configurable parameters provided in the equipment.

D. Building Materials and Finishes Operation and Maintenance Manual Content:
    1. Provide a cover page as the first page of each manual with the following information:
        a. Manufacturer(s) Name and Contact Information.
        b. Vendor's Name and Contact Information.
        c. Date (month, year).
        d. Project Owner and Project Name.

e. Specification Section.
f. Model Numbers.
g. Engineer's Name.
h. Contractor's Name.

2. Provide a Table of Contents for each manual.
3. Building products, applied materials and finishes:
   a. Include product data, with catalog number, size, composition and color and texture designations.
   b. Provide information for ordering custom manufactured products.
4. Necessary precautions:
   a. Include product MSDS for each approved product.
   b. Include any precautionary application and storage guidelines.
5. Instructions for care and maintenance:
   a. Include manufacturer's recommendations for cleaning agents and methods, precautions against detrimental agents and methods and recommended schedule for cleaning and maintenance.
6. Moisture protection and weather exposed products:
   a. Include product data listing, applicable reference standards, chemical composition, and details of installation.
   b. Provide recommendations for inspections, maintenance and repair.
7. Additional requirements as specified in individual product specifications.

E. National Fire Protection Association 70 (National Electrical Code) Documentation:
1. Assemble documented calculations of Arc-Fault Current, Equipment Available Fault Current and Short Circuit Current Rating (SCCR) provided as part of equipment submittals into one O&M manual volume.

1.6 TRANSMITTAL OF SUBMITTALS

A. Operation and Maintenance Manuals.
1. Transmit all submittals to:
   a. The address specified in Specification Section 01 33 00 - SUBMITTALS.
2. Transmittal form: Use Operation and Maintenance Manual Transmittal, Exhibit A.
3. Transmittal numbering:
   a. Number each submittal with the Specification Section number followed by a series number beginning with "-01" and increasing sequentially with each additional transmittal, followed by "-OM" (for example: 43 23 14-01-OM).
4. Submit draft and final Operation and Maintenance Manual in electronic format (PDF) to Engineer, until manual is approved.

1.7 ENGINEER'S REVIEW ACTION

A. Draft Electronic (PDF) Submittals:
1. Engineer will review and indicate one of the following review actions:
   a. A - ACCEPTABLE
   b. B - FURNISH AS NOTED
   c. C - REVISE AND RESUBMIT
   d. D - REJECTED
2. Submittals marked as Acceptable or Furnish As Noted will be retained; however, the transmittal form will be returned with a request for the final paper and electronic documents to be submitted.
3. Copies of submittals marked as Revise and Resubmit or Rejected will be returned with the transmittal form marked to indicate deficient areas.
4. Resubmit until approved.

B. Final Paper Copy Submittals:
1. Engineer will review and indicate one of the following review actions:
   a. A - ACCEPTABLE

b. D - REJECTED

2. Submittals marked as Acceptable will be retained with the transmittal form returned as noted.
3. Submittals marked as Rejected will be returned with the transmittal form marked to indicate deficient areas.
4. Resubmit until approved.

PART 2 - PRODUCTS - (NOT USED)

PART 3 - EXECUTION - (NOT USED)

END OF SECTION

EXHIBIT A **Operation and Maintenance Manual Transmittal _____-_____ - OM**

(Spec Section) (Series) .

Project Name: Date Received:

Project Owner: Checked By:

Contractor: Owner: Log Page:

Address: Address: HDR No.:

Attn: Attn:

1st. Sub. ReSub.

Date Transmitted: Previous Transmittal Date:

No. Copies	Description of Item	Manufacturer	Dwg. or Data No.	Action Taken*

Remarks:

To: From:

HDR Engineering, Inc.

Date:

* The Action designated above is in accordance with the following legend:

A - Acceptable, provide one (1) additional paper copy and two (2) Electronic Documents (in portable document format, PDF files) by Electronic Means for final review.

B - Furnish as Noted

C - Revise and Resubmit

This Operation and Maintenance Manual Submittal is deficient in the following area:

1. Equipment Records.
2. Functional description.
3. Assembly, disassembly, installation, alignment, adjustment & checkout instructions.
4. Operating instructions.
5. Lubrication & maintenance instructions.
6. Troubleshooting guide.
7. Parts list and ordering instructions.
8. Organization (binder, binder titles, index & tabbing).
9. Wiring diagrams & schematics specific to installation.
10. Outline, cross section & assembly diagrams.
11. Test data & performance curves.
12. Tag or equipment identification numbers.
13. Inclusion of all components & subcomponents.
14. Other - see comments.

D - Rejected

Comments:

By Date

Distribution: Contractor File Field Owner Other

EXHIBIT B1

Equipment Record

Equipment Data and Spare Parts Summary

Project Name	Specification Section:
Equipment Name	Year Installed:
Project Equipment Tag No(s).	
Equipment Manufacturer	Project/ Order No.
Address	Phone
Fax / Web Site / E-mail	
Local Vendor/Service Center	
Address	Phone
Fax / Web Site / E-mail	

MECHANICAL NAMEPLATE DATA

Equip.		Serial No.		
Make		Model No.		
ID No.	Frame No.	HP	RPM	Cap.
Size	TDH	Imp. Sz.	CFM	PSI
Other:				

ELECTRICAL NAMEPLATE DATA

Equip.			Serial No.					
Make			Model No.					
ID No.	Frame No.	HP	V.	Amp.	HZ	PH	RPM	SF
Duty	Code	Ins. Cl.	Type	NEMA	C Amb.	Temp. Rise	Rating	
Other:								

SPARE PARTS PROVIDED PER CONTRACT

Part No.	Part Name	Quantity

RECOMMENDED SPARE PARTS

Part No.	Part Name	Quantity

EXHIBIT B2

Equipment Record

Recommended Maintenance Summary

Equipment Description	Project Equip. Tag No(s).	

RECOMMENDED BREAK-IN MAINTENANCE (FIRST OIL CHANGES, ETC.)	INITIAL COMPLETION * FOLLOWING START-UP							
	D	W	M	Q	S	A	RT	Hours

RECOMMENDED PREVENTIVE MAINTENANCE	PM TASK INTERVAL *							
	D	W	M	Q	S	A	RT	Hours

***** **D = Daily** **W = Weekly** **M = Monthly** **Q = Quarterly** **S = Semiannual** **A = Annual** **Hours = Run Time Interval**

EXHIBIT B3

Equipment Record

Lubrication Summary

Equipment Description	Project Equip. Tag No(s).

Lubricant Point						
Lubricant Type		Manufacturer	Product	AGMA #	SAE #	ISO
	1					
	2					
	3					
	4					
	5					

Lubricant Point						
Lubricant Type		Manufacturer	Product	AGMA #	SAE #	ISO
	1					
	2					
	3					
	4					
	5					

Lubricant Point						
Lubricant Type		Manufacturer	Product	AGMA #	SAE #	ISO
	1					
	2					
	3					
	4					
	5					

Lubricant Point						
Lubricant Type		Manufacturer	Product	AGMA #	SAE #	ISO
	1					
	2					
	3					
	4					
	5					

Lubricant Point						
Lubricant Type		Manufacturer	Product	AGMA #	SAE #	ISO
	1					
	2					
	3					
	4					
	5					

Lubricant Point						
Lubricant Type		Manufacturer	Product	AGMA #	SAE #	ISO
	1					
	2					
	3					
	4					
	5					

SECTION 01 61 03
EQUIPMENT - BASIC REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Requirements of this Specification Section apply to all equipment provided on the Project including those found in other Divisions even if not specifically referenced in individual "Equipment" Articles of those Specification Sections.

B. Related Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Section 03 31 30 - Concrete, Materials and Proportioning.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. ASTM International (ASTM):
      a. E1934, Standard Guide for Examining Electrical and Mechanical Equipment with Infrared Thermography.
      b. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
   2. International Electrotechnical Commission (IEC).
   3. Institute of Electrical and Electronics Engineers, Inc. (IEEE).
   4. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   5. InterNational Electrical Testing Association (NETA):
      a. ATS, Acceptance Testing Specification for Electrical Power Distribution Equipment and Systems.
   6. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC):
   7. Occupational Safety and Health Administration (OSHA):
      a. 29 CFR 1910, Occupational Safety and Health Standards, referred to herein as OSHA Standards.
   8. Underwriters Laboratories, Inc. (UL).
      a. 508, Standard for Safety Industrial Control Equipment.
      b. 508A, Standard for Safety Industrial Control Panels.

B. Electrical Equipment and Connections Testing Program:
   1. Field personnel:
      a. Minimum of one year field experience covering all phases of electrical equipment inspection, testing, and calibration.
      b. Relay test technician having previous experience with testing and calibration of relays of the same manufacturer and type used on project and proficient in setting and testing the types of protection elements used.
   2. Analysis personnel:
      a. Minimum three years combined field testing and data analysis experience.

C. Miscellaneous:
   1. A single manufacturer of a "product" shall be selected and utilized uniformly throughout Project even if:
      a. More than one manufacturer is listed for a given "product" in Specifications.
      b. No manufacturer is listed.

1.3 DEFINITIONS

A. Product: Manufactured materials and equipment.

B. Major Equipment Supports - Supports for Equipment:
   1. Located on or suspended from elevated slabs with supported equipment weighing 2000 LBS or greater, or;
   2. Located on or suspended from roofs with supported equipment weighing 500 LBS or greater, or;
   3. Located on slab-on-grade or earth with supported equipment weighing 5000 LBS or more.

C. Equipment:
   1. One or more assemblies capable of performing a complete function.
   2. Mechanical, electrical, instrumentation or other devices requiring an electrical, pneumatic, electronic or hydraulic connection.
   3. Not limited to items specifically referenced in "Equipment" articles within individual Specifications.

D. Installer or Applicator:
   1. Installer or applicator is the person actually installing or applying the product in the field at the Project site.
   2. Installer and applicator are synonymous.

1.4 SUBMITTALS

A. Shop Drawings:
   1. General for all equipment:
      a. See Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
      b. Data sheets that include manufacturer's name and complete product model number.
         1) Clearly identify all optional accessories that are included.
      c. Acknowledgement that products submitted comply with the requirements of the standards referenced.
      d. Manufacturer's delivery, storage, handling, and installation instructions.
      e. Equipment identification utilizing numbering system and name utilized in Drawings.
      f. Equipment installation details:
         1) Location of anchorage.
         2) Type, size, and materials of construction of anchorage.
         3) Anchorage setting templates.
         4) Manufacturer's installation instructions.
      g. Equipment area classification rating.
      h. Shipping and operating weight.
      i. Equipment physical characteristics:
         1) Dimensions (both horizontal and vertical).
         2) Materials of construction and construction details.
      j. Equipment factory primer and paint data.
      k. Manufacturer's recommended spare parts list.
      l. Equipment utility requirements include air, natural gas, electricity, and water.
      m. Fabrication and/or layout drawings:
         1) Dimensioned outlined drawing.
         2) Connection diagrams including accessories (strip heaters, thermal protection, etc.).
      n. Electrical gear:
         1) Unless specified in a narrow-scope Specification Section, provide the following:
            a) Equipment ratings: Voltage, continuous current, kVa, watts, short circuit with stand, etc., as applicable.
         2) Control panels:
            a) Panel construction.
            b) Point-to-point ladder diagrams.

c) Scaled panel face and subpanel layout.
d) Technical product data on panel components.
e) Panel and subpanel dimensions and weights.
f) Panel access openings.
g) Nameplate schedule.
h) Panel anchorage.
i) Short Circuit Current Rating (SCCR) nameplate marking per NFPA 70. Include any required calculations.

2. Systems schematics and data:
   a. Provide system schematics where required in system specifications.
      1) Acknowledge all system components being supplied as part of the system.
      2) Utilize equipment, instrument and valving tag numbers defined in the Contract Documents for all components.
      3) Provide technical data for each system component showing compliance with the Contract Document requirements.
      4) For piping components, identify all utility connections, vents and drains which will be included as part of the system.
3. Qualifications for:
   a. Electrical equipment and connections testing firm and personnel.
4. Equipment Monitoring and Testing plans, in accordance with PART 3 of this Specification Section:
   a. Electrical equipment and connection testing.

B. Factory Test Reports:
   1. Equipment performance tests.
      a. As listed in individual equipment specifications.

C. Contract Closeout Information:
   1. Operation and Maintenance Data:
      a. See Section 01 33 04 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

D. Informational Submittals:
   1. Notification, at least one week in advance, that testing will be conducted at factory.
   2. Certification from equipment manufacturer that all manufacturer-supplied control panels that interface in any way with other controls or panels have been submitted to and coordinated with the supplier/installer of those interfacing systems.
   3. Submit sample Manufacturer's Field Service Report (MFSR). Report shall use manufacturer’s standard report or use the form in the Exhibits and have at least the following information:
      a. Certification that equipment has been installed properly, has been initially started up, has been calibrated and/or adjusted as required, and is ready for operation.
      b. Certification for major equipment supports that equipment foundation design loads shown on the Drawings or specified have been compared to actual loads exhibited by equipment provided for this Project and that said design loadings are equal to or greater than the loads produced by the equipment provided.
      c. Certification prior to Project closeout that electrical panel drawings for manufacturer-supplied control panels truly represent panel wiring including any field-made modifications.
      d. Testing and monitoring reports in accordance with PART 3 of this Specification Section.
   4. Submit completed Manufacturer's Field Service Report (MFSR) for each piece of equipment supplied.

PART 2 - PRODUCTS

2.1 ACCESSORIES

A. Anchorage:
   1. Cast-in-place anchorage:
      a. Provide ASTM F593, Type 316 stainless steel anchorage for all equipment.
      b. Configuration and number of anchor bolts shall be per manufacturer's recommendations.
      c. Provide two nuts for each bolt.
   2. Drilled anchorage:
      a. Epoxy grout per Section 03 31 30.
      b. Threaded rods same as cast-in-place.

B. Data Plate:
   1. Permanently stamp information on data plate including manufacturer's name, equipment operating parameters, serial number and speed.

C. Lifting Eye Bolts or Lugs:
   1. Provide on all equipment 50 LBS or greater.
   2. Provide on other equipment or products as specified in the narrow-scope Specification Sections.

2.2 FABRICATION

A. Design, fabricate, and assemble equipment in accordance with modern engineering and shop practices.

B. Manufacture individual parts to standard sizes and gages so that repair parts, furnished at any time, can be installed in field.

C. Furnish like parts of duplicate units to be interchangeable.

D. Ensure that equipment has not been in service at any time prior to delivery, except as required by tests.

E. Furnish equipment which requires periodic internal inspection or adjustment with access panels which will not require disassembly of guards, dismantling of piping or equipment or similar major efforts.
   1. Quick opening but sound, securable access ports or windows shall be provided for inspection of chains, belts, or similar items.

F. Provide common, lipped base plate mounting for equipment and equipment motor where said mounting is a manufacturer's standard option.
   1. Provide drain connection for 3/4 IN PVC tubing.

G. Control Panels Engineered and Provided with the Equipment by the Manufacturer:
   1. Manufacturer’s standard design for components and control logic unless specific requirements are specified in the specific equipment Specification Section.
   2. NEMA or IEC rated components are acceptable, whichever is used in the manufacturer’s standard engineered design, unless specific requirements are required in the specific equipment Specification Section.
   3. Affix entire assembly with a UL 508A or UL 698A label "Listed Enclosed Industrial Control Panel" prior to delivery.
      a. Control panels without an affixed UL 508A or UL 698A label shall be rejected.
   4. Provide equipment or control panels with Short Circuit Current Rating (SCCR) labeling as required by NFPA 70 and other applicable codes.
      a. Determine the SCCR rating by one of the following methods:
         1) Method 1: SCCR rating meets or exceeds the available fault current of the source equipment when indicated on the Drawings.

2) Method 2: SCCR rating meets or exceeds the source equipment's Amp Interrupting Current (AIC) rating as indicated on the Drawings.
3) Method 3: SCCR rating meets or exceeds the calculated available short circuit current at the control panel.

b. The source equipment is the switchboard, panelboard, motor control center or similar equipment where the control panel circuit originates.
c. For Method 3, provide calculations justifying the SCCR rating. Utilize source equipment available fault current or AIC rating as indicated on the Drawings.

2.3 SHOP OR FACTORY PAINT FINISHES

A. Electrical Equipment:
1. Provide factory-applied paint coating system(s) for all electrical equipment components to receive field painting.

B. Field paint other equipment in accordance with factory applied primer/field paint compatibility requirements.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment as shown on Drawings and in accordance with manufacturer's directions.

B. Utilize templates for anchorage placement for slab-mounted equipment.
1. Route clear of major traffic areas and as approved by Engineer.

C. DO NOT construct foundations until major equipment supports are approved.

D. Equipment Base:
1. Construct level in both directions.
2. Take particular care at anchor bolt locations so these areas are flat and level.

E. Grouting:
1. After machine base has been shimmed, leveled onto equipment base with jack screws, couplings aligned and mounting bolts tightened to correct torque value, place a dam or formwork around base to contain grouting between equipment base and equipment support pad.
a. Extend dam or formwork to cover leveling shims and blocks.
b. Grease anchor bolts and jack screws to inhibit grout form adhering to bolts.
c. If anchor sleeve were used, fill voids in anchor sleeves with foam to keep grout from filling sleeves.
d. Do not use nuts below the machine base to level the unit.
2. Saturate top of roughened concrete subbase with water before grouting.
a. Add grout until entire space under machine base is filled to the top of the base underside.
b. Puddle grout by working a stiff wire through the grout and vent holes to work grout in place and release any entrained air in the grout or base cavity.
3. When the grout has sufficiently hardened, remove dam or formwork and finish the exposed grout surface to fine, smooth surface.
a. Cover exposed grout surfaces with wet burlap and keep covering sufficiently wet to prevent too rapid evaporation of water from the grout.
b. When the grout has fully hardened (after a minimum of seven days), remove jack screws, tighten all anchor bolts to engage equipment base to grout, shims, and equipment support pad.
c. Recheck driver-driven unit for proper alignment.

3.2 INSTALLATION CHECKS

A. For all equipment specifically required in detailed specifications, secure services of experienced, competent, and authorized representative(s) of equipment manufacturer to visit site of work and inspect, check, adjust and approve equipment installation.
   1. In each case, representative(s) shall be present during placement and start-up of equipment and as often as necessary to resolve any operational issues which may arise.

B. No separate payment shall be made for installation checks.
   1. All or any time expended during installation check does not qualify as Operation and Maintenance training or instruction time when specified.

3.3 IDENTIFICATION OF EQUIPMENT AND HAZARD WARNING SIGNS

A. Identify equipment and install hazard warning signs in accordance with Section 10 14 00.

3.4 WIRING CONNECTIONS AND TERMINATION

A. Clean wires before installing lugs and connectors.

B. Coat connection with oxidation eliminating compound for aluminum wire.

C. Tape stripped ends of conductors and associated connectors with electrical tape.
   1. Wrapping thickness shall be 150 percent of the conductor insulation thickness.

D. Connections to carry full ampacity of conductors without temperature rise.

E. Terminate spare conductors with electrical tape.

3.5 FIELD QUALITY CONTROL

A. General:
   1. Furnish equipment manufacturer's field quality control services and testing as specified in the individual equipment Specification Sections.
   2.
   3. Perform and report on all tests required by the equipment manufacturer's Operation and Maintenance Manual.
   4. Provide testing of electrical equipment and connections in accordance with the Electrical specifications.
   5. Equip testing and analysis personnel with all appropriate project related reference material required to perform tests, analyze results, and provide documentation including, but not limited to:
      a. Contract Drawings and Specifications.
      b. Related construction change documentation.
      c. Approved Shop Drawings.
      d. Approved Operation and Maintenance Manuals.
      e. Other pertinent information as required.

B. Equipment Monitoring and Testing Plans:
   1. Approved in accordance with Shop Drawing submittal schedule.
   2. Included as a minimum:
      a. Qualifications of firm, field personnel, and analysis personnel doing the Work.
      b. List and description of testing and analysis equipment to be utilized.
      c. List of all equipment to be testing, including:
         1) Name and tag numbers identified in the Contract Documents.
         2) Manufacturer's serial numbers.
         3) Other pertinent manufacturer identification,

C. Instruments Used in Equipment and Connections Quality Control Testing:
   1. Minimum calibration frequency:
      a. Field analog instruments: Not more than 6 months.
      b. Field digital instruments: Not more than 12 months.

c. Laboratory instruments: Not more than 12 months.
d. If instrument manufacturer's calibration requirements are more stringent, those requirements shall govern.

2. Carry current calibration status and labels on all testing instruments.
3. See individual testing programs for additional instrumentation compliance requirements.

D. Electrical Equipment and Connections Testing Program:
1. Perform testing on Electrical equipment and connections in accordance with the Electrical specification requirements.
2. Repair or replace equipment shown to be out of range of the acceptable tolerance until the equipment meets or exceeds acceptability standards.

E. Other Testing:
1. Perform tests and inspections not specifically listed but required to assure equipment is safe to energize and operate.
2. Subbase that supports the equipment base and that is made in the form of a cast iron or steel structure that has supporting beams, legs, and cross members that are cast, welded, or bolted shall be tested for a natural frequency of vibration after equipment is mounted.
a. The ratio of the natural frequency of the structure to the frequency of the disturbing force shall not be between 0.5 and 1.5.

3.6 DEMONSTRATION

A. Demonstrate equipment in accordance with Section 01 75 00.

END OF SECTION

EXHIBIT A

MANUFACTURER FIELD SERVICE REPORT

This field service report is generic in nature. An electronic copy of this form will be furnished upon request from the Engineer. This report is to reflect that all requirements of the Operations and Maintenance Manual and the individual equipment specification requirements have been performed for the installation and operation and also to provide a baseline for amperage draw for each phase, vibration readings, rotation, alignment and all other applicable tests required to insure that the equipment has been installed properly. A MFSR will be required for each individual piece of equipment requiring a MFSR.

Definitions of Reports:

Initial service report: Required for construction preparations. Equipment delivered to site is in good condition and conforms to specification requirements. Anchor bolts, hardware and ancillary items (piping, flanges, conduits, fuel/power supply) are compatible with equipment.

Interim service report: Required for equipment installation onto base or foundation. Piping connections, electrical and control connections or structural attachment are complete. For equipment stored on site over four weeks, interim service report will document that manufacturer's long-term storage procedures have been incorporated and equipment has not been damaged, nor coatings deteriorated.

Final service report is to be completed when equipment can be started, electrical amperage and voltage draw measured, cold and hot alignments performed, vibration testing and monitoring performed and the equipment is found to be in compliance with Manufacturer's operating parameters and the requirements of the individual equipment specifications.

PROJECT: _____

Report Status:

Initial Service Report completed and submitted on _____

Interim Service Report completed and submitted on _____

Final Service Report completed and submitted on _____

Commencement of Warranty _____

I Description

A. Equipment Name and Identification: _____

_____

B. Serial Number: _____

C. Specification Section Number: _____

D. Manufacturer: _____

E. Representative: _____

F. Type of Service: Initial _____ Interim _____ Final _____

II General Review

A. The above referenced equipment/material/supplies have been inspected, checked, and adjusted. Yes _____ No _____

Summary: _____

_____

B. The above referenced equipment/material/supplies were placed upon properly prepared or suitable substrate. N/A _____ Yes _____ No _____

Summary: _____

_____

C. The above referenced equipment/material/supplies are free from any undue stress imposed by any connected piping, anchor bolts or any other load. N/A _____ Yes _____ No _____

Summary: _____

_____

D. The above referenced equipment/material/supplies have operated under design conditions. N/A _____ Yes _____ No _____

Summary: _____

_____

E. The above referenced equipment/material/supplies have been installed in accordance with the manufacturer's recommendations and the Procurement Documents, require no corrective work, and are hereby approved. Yes _____ No _____

Summary: _____

_____

F. The above referenced equipment/material/supplies are acceptable to the manufacturer as installed providing the following corrective action(s) are performed:

1. _____
2. _____
3. _____
4. _____
5. _____

III Inspection Checklist

Item	Acceptable (Yes/No)	Readings/Comments
Bearings (1)		
Belts (tension reading)		
Lubrication Levels		
Vibration (1) (2) (MILS/SEC)		
Infrared Thermography (1) (2)		
Starting AMPS		
Full Load AMPS		
Volts		
Rotation		
Jacket Temperature (DEGF)		
Seal Water Flow Rate (GPH or GPM)		
Seal Water Pressure (PSI)		
O-rings/Packing		
Alignment (1)		
Anchor Bolts		
Grout		

Item	Acceptable (Yes/No)	Readings/Comments
Substrate Approval		
Sound level (4 FT from unit) (1) (dB)		
Other		

(1) Inspection or testing reports must be attached.
(2) Provide vibration testing and monitoring procedures for Engineer's review and approval prior to testing.

IV O&M Manuals

A. The O&M manual as presented contains all information required for proper operation, maintenance, and instruction of this system. N/A _____ Yes _____ No _____

Summary: _____

_____

V Preventive Maintenance

A. The preventive maintenance summary outlined in the O&M manual is acceptable for operation of the system throughout the warranty period. N/A _____ Yes _____ No _____

Summary: _____

_____

VI Operator Training/Classroom Instruction

A. Training and instruction have been performed in accordance with the requirements of the Procurement Documents. N/A _____ Yes _____ No _____

B. Final Training/Classroom Instruction Completed on: _____

Summary: _____

_____

VII Remarks

_____

_____

_____

VIII Certification

I hereby certify, that I, _____, am a duly authorized representative of the manufacturer, that I am empowered by the manufacturer to inspect, approve, and operate his equipment, and that I am authorized to make recommendations required to assure that the equipment furnished by the manufacturer is complete and operational, except as modified herein. I also certify that all information contained herein is true and accurate.

By: _____
(Authorized Representative)

For: _____

Date: _____

IX Acknowledgments

By: _____

For: _____
(Contractor)

Date: _____

By: _____

For: _____
(Engineer)

Date: _____

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SECTION 01 65 50
PRODUCT DELIVERY, STORAGE, AND HANDLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Scheduling of product delivery.
   2. Packaging of products for delivery.
   3. Protection of products against damage from:
      a. Handling.
      b. Exposure to elements or harsh environments.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.

C. Payment:
   1. No payment will be made to Contractor for equipment or materials not properly stored and insured or without approved Shop Drawings.
      a. Previous payments for items will be deducted from subsequent progress estimate(s) if proper storage procedures are not observed.

1.2 DELIVERY

A. Scheduling: Schedule delivery of products or equipment as required to allow timely installation and to avoid prolonged storage.

B. Packaging: Deliver products or equipment in manufacturer's original unbroken cartons or other containers designed and constructed to protect the contents from physical or environmental damage.

C. Identification: Clearly and fully mark and identify as to manufacturer, item, and installation location.

D. Protection and Handling: Provide manufacturer's instructions for storage and handling.

PART 2 - PRODUCTS - (NOT USED)

PART 3 - EXECUTION

3.1 PROTECTION, STORAGE AND HANDLING

A. Manufacturer's Instruction:
   1. Protect all products or equipment in accordance with manufacturer's written directions.
      a. Store products or equipment in location to avoid physical damage to items while in storage.
      b. Handle products or equipment in accordance with manufacturer's recommendations and instructions.
   2. Protect equipment from exposure to elements and keep thoroughly dry.
   3. When space heaters are provided in equipment, connect and operate heaters during storage until equipment is placed in service.

3.2 FIELD QUALITY CONTROL

A. Inspect Deliveries:
   1. Inspect all products or equipment delivered to the site prior to unloading.

a. Reject all products or equipment that are damaged, used, or in any other way unsatisfactory for use on Project.

B. Monitor Storage Area: Monitor storage area to ensure suitable temperature and moisture conditions are maintained as required by manufacturer or as appropriate for particular items.

END OF SECTION

SECTION 01 73 29
CUTTING AND PATCHING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. General requirements for cutting and patching Work.

B. Scope:
   1. Contractor shall perform cutting and coring, and rough and finish patching of holes and openings in existing construction.
   2. Provide cutting, coring, fitting, and patching, including attendant excavation and fill, required to complete the Work, and to:
      a. remove and replace defective Work;
      b. remove samples of installed Work as specified or required for testing;
      c. remove construction required to perform required alterations or additions to existing construction;
      d. uncover the Work for Engineer's observation of covered Work, testing, or inspection by testing entities, or observation by authorities having jurisdiction;
      e. connect to completed Work not performed in proper sequence;
      f. remove or relocate existing utilities and piping that obstruct the Work in locations where connections are to be made;
      g. make connections or alterations to existing or new facilities.
   3. Cutting, coring, and rough patching shall be performed by the prime contractor requiring the opening. Finish patching shall be responsibility of General Contractor and shall be performed by Subcontractor or trade associated with application of the particular finish.

C. Related Requirements:
   1. Section 03 31 30 - Concrete, Materials and Proportioning.
   2. Section 03 35 00 - Concrete Finishing and Repair of Surface Defects.
   3. Section 31 23 33 - Trenching, Backfilling, and Compacting for Utilities.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1.3 SUBMITTALS

A. Action Submittals: Submit the following:
   1. Cutting and Patching Request:
      a. Submit written request to Engineer, well in advance of executing cutting or alteration that affects one or more of the following:
         1) Design function or intent of Project.
         2) Work of Owner or other contractors retained by Owner.
         3) Structural capacity or integrity of an element of the Project, building, or structure.
         4) Integrity or effectiveness of weather-exposed or moisture-resistant elements or systems.
         5) Efficiency, operational life, maintenance, or safety of operational elements.
         6) Visual qualities of elements that will be exposed to view after completion of the Work.
      b. Request shall include:
         1) Identification of Project and Contract designation.
         2) Description of affected Work of Contractor and work of others (if any) retained by Owner.
         3) Necessity for cutting.

4) Effect on work or operations of Owner and other contractors (if any) retained by Owner, and on structural and weatherproof integrity of Project, building, or structure.
5) Description of proposed Work, indicating: scope of cutting and patching; trades that will execute the cutting and patching Work; materials and equipment to be used; extent of refinishing; schedule of operations; alternatives (if any) to cutting and patching, and net effect on aesthetics following completion of finishing Work.
6) Indication of entity responsible for cost of cutting and patching, when applicable.
7) Written permission of other prime contractors (if any) whose work will or may be affected.

2. Recommendation Regarding Cutting and Patching:
   a. Should conditions of work or schedule indicate a change of materials or specified methods, furnish Submit written recommendation to Engineer including:
      1) Conditions indicating change.
      2) Recommendations for alternative materials or alternatives to specified methods.
      3) Material manufacturer's printed recommendations for the proposed product and recommendations of manufacturer's technical representative for the specific application(s). The latter shall be on technical representative's letterhead and shall explicitly indicate the Project and specific cutting and patching application(s) to which the recommendation(s) apply.
      4) Items required with request for approval of substitute, in accordance with the substitution request requirements of the Contract Documents.
3. Product Data:
   a. Submit manufacturer's published data for the protective compound to be applied to core-drilled surfaces and cut concrete surfaces.
   b. When not required under other Specifications sections, submit manufacturer's published data on materials to be used for finishing around the cut or patched area(s), together with indication of the location(s) where each is proposed for use.
   c. Furnish Submittals for patching materials under the associated Specifications section. Submittal to include letter of recommendation from product manufacturer's technical representative indicating on technical representative's letterhead, explicitly indicating:
      1) Project name and facility name;
      2) specific cutting and patching application(s) to which the recommendations apply;
      3) that product manufacturer's technical representative has personally observed and is familiar with conditions in the work area(s) of the subject cutting and patching;
      4) materials that are the subject of the Submittal are appropriate for the condition(s) of the proposed patch and will remain durable in the patch's final exposure upon Substantial Completion; and.
      5) patching material manufacturer's technical representative's recommendations for surface preparation, installation of patching material(s), and curing.

B. Informational Submittals: Submit the following:
   1. Written Notification of Cutting and Patching:
      a. Furnish as a Submittal written indication designating the day and time that the construction associated with cutting and patching will be uncovered to allow for observation. Do not begin cutting or patching operations until submittal is accepted by Engineer.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials – General:
   1. Provide materials that comply with the Contract Documents.
   2. If not shown or indicated in the Contract Documents, use materials identical to existing materials affected by cutting and patching Work.

3. For exposed surfaces, use materials that visually match existing adjacent surfaces to fullest extent possible. If identical materials are unavailable or cannot be used, provide materials whose installed performance will equal or surpass that of existing materials.
4. Replace, patch, and repair materials and surfaces cut or damaged during cutting and patching operations, using materials that do not void required or existing warranties.

B. Compound Applied to Core-Drilled Surfaces and Cut Concrete Surfaces:
1. After core-drilling or sawcutting (as applicable) and before installing the utility or equipment through the penetration, coat exposed concrete and exposed steel with solvent-free, two-component, protective, epoxy resin coating.
2. Color shall approximate the finish color of the existing surface to be coated.
3. Product and Manufacturer: Subject to compliance with the Contract Documents, the following products and manufacturers are acceptable:
a. Sikagard 62, by Sika Corporation.
b. Or equal.

C. Grout Materials:
1. Comply with Section 03 31 30 - Concrete, Materials and Proportioning.

D. Epoxy Bonding Adhesive:
1. Provide two-component, moister-insensitive adhesive manufactured for the purpose of bonding fresh concrete to hardened concrete.
2. Comply with Section 03 31 30 - Concrete, Materials and Proportioning.
3. Product and Manufacturer: Subject to compliance with the Contract Documents, the following products and manufacturers are acceptable:
a. Euco No.452 MV by Euclid Chemical Co.
b. Sikadur 32, Hi-Mod by Sika Corporation.
c. Or equal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examination and Assessment – General:
1. Examine surfaces to be cut or patched, and conditions under which cutting or patching will be performed before starting cutting or patching Work.
2. Report unsatisfactory or questionable conditions to Engineer in writing.
3. Do not proceed with cutting or patching Work until unsatisfactory conditions are corrected.

3.2 PREPARATION

A. Provide temporary support required to maintain structural integrity of facilities, to protect adjacent work from damage during cutting, and to support the element(s) to be cut.

B. Protection of Existing Construction during Cutting and Patching:
1. Protect existing construction during cutting and patching to prevent damage. Provide protection from adverse weather conditions for portions of the Project and facility that will be exposed during cutting and patching operations.
2. Avoid interference with use of adjoining areas or interruption of free passage to adjoining areas.
3. Do not cut existing pipe, conduit, ductwork, or other utilities serving facilities scheduled to be removed or relocated until provisions have been made to bypass them.

3.3 CUTTING AND PATCHING – GENERAL

A. Perform cutting and coring in such manner that limits extent of patching required.

B. Structural Elements:
1. Do not cut or patch structural elements in manner that would change the element's structural load-carrying capacity as load deflection ratio.

C. Operating Elements:
   1. Do not cut or patch operating elements in manner that would reduce their capacity to perform as intended.
   2. Do not cut or patch operating elements or related components in manner that would increase maintenance requirements or decrease operational life or safety.

D. Replace, patch, and repair materials and surfaces cut or damaged during cutting and patching operations, using methods that do not void required or existing warranties.

E. Provide adequate temporary covering over openings (whether cut or core-drilled) where not in use. Avoid creating tripping hazards for openings provided in floors and slabs.

3.4 CORING

A. Use core-drilling to make penetrations through concrete and masonry walls, slabs, or arches, unless otherwise accepted by Engineer in writing.

B. Coring:
   1. Perform coring with non-impact rotary tool using diamond core-drills. Size holes for pipe, conduit, sleeves, equipment or mechanical seals, as required, to be installed through the penetration.
   2. Do not core-drill through electrical conduit or other utilities embedded in walls or slabs without approval of Engineer. To extent possible, avoid cutting reinforcing steel in slabs and walls.

C. Protection:
   1. Protect existing equipment, utilities, and adjacent areas from water and other damage caused by or resulting from core-drilling operations.
   2. After core-drilling and before installing the utility or equipment through the penetration, coat exposed concrete and steel with protective coating material indicated in Paragraph 2.1.B of this Specification Section. Apply protective coating in accordance with manufacturer's instructions.

D. Cleaning:
   1. After core-drilling, vacuum or otherwise remove slurry and tailings from the work area.

3.5 CUTTING

A. Cutting – General:
   1. Cut existing construction using methods least-likely to damage elements retained and adjoining construction and that provide proper surfaces to receive subsequent installation or repair.
   2. In general, use hand tools or small power tools suitable for sawing or grinding. When possible, avoid using hammering and avoid chopping. Carefully chip out concrete where necessary and as indicated in the Contract Documents.
   3. Cut holes and slots as small as possible, neatly to the size required, and with minimum disturbance of adjacent surfaces.
   4. Prior to starting cutting, provide adequate bracing of area to be cut.
   5. To avoid marring existing finished surfaces, cut or drill from exposed or finished side into concealed side.
   6. Use equipment of adequate size to remove the cut panel or "coupon".

B. Cutting – Concrete and Masonry:
   1. Cut through concrete and masonry using concrete wall saw with diamond saw blades.
   2. On both sides of the element being cut, provide for control of slurry generated during sawing.
   3. Concrete Cutting:
      a. Make openings by sawing through existing concrete. Core drill with 6 IN DIA core at the corners of openings to avoid overcutting at corners.

b. When the cut-out concrete or "coupon" cannot be removed in one piece, or where concrete is too thick for saw to penetrate fully, break out concrete after initial saw cuts.
c. Where saw cutting is not possible:
    1) Make openings by drilling holes around perimeter of required opening and subsequently carefully chip out concrete.
    2) Holes shall be sufficient in quantity to prevent damage to remaining concrete.

4. Sizing and Repair of Cut Concrete Surfaces:

3.6 PATCHING

A. Patching – General:
1. Patch large openings to be filled with concrete in accordance with the Contract Documents. Before installing new concrete, apply bonding adhesive indicated in Paragraph 2.1.C of this Specifications section in accordance with manufacture's recommendations.
2. Patch construction by filling, repairing, refinishing, closing-up, and similar operations following performance of other Work.
3. Patch with durable seams that are as inconspicuous as possible. Provide materials and comply with installation requirements indicated in the Contract Documents and the published installation instructions of the material's manufacturer.
4. Patch to provide airtight and watertight connections to pipes, sleeves, ducts, conduit, and other penetrations through surfaces.
5. Where feasible, test patched areas to demonstrate integrity of installation.

B. Restoration:
1. Restore exposed finishes of patched areas and extend finish restoration into retained adjoining construction in manner that eliminates evidence of patching and refinishing.
2. For continuous surfaces, refinish to nearest intersection.
3. For an assembly, refinish the entire unit that was patched.
4. Patch, repair, or rehang existing ceilings as necessary to provide an even-plane surface of uniform appearance.

3.7 CLEANING

A. Cleaning and Restoration:
1. Perform cleaning promptly after associated cutting, coring, and patching.
2. Clean areas and spaces where cutting, coring, or patching were performed.
3. Clean piping, conduit, and similar constructions before applying paint or other finishing materials.
4. Restore damaged coverings of pipe and other utilities to original condition.

END OF SECTION

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SECTION 01 74 00
CLEANING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Requirements for keeping the Site free of accumulations of waste materials during construction ("progress cleaning").
   2. Cleaning for Substantial Completion and prior to final inspection (collectively, "closeout cleaning").

B. Scope:
   1. Contractor shall perform cleaning during the Project, including progress cleaning, as condition precedent to Substantial Completion, upon completion of the Work, and as required by the General Conditions, as may be modified by the Supplementary Conditions, this Specifications section, and elsewhere in the Contract Documents.
   2. Maintain in a clean manner the Site, the Work, and areas adjacent to or affected by the Work.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. National Fire Protection Association (NFPA):
      a. 241, Safeguarding Construction, Alteration, and Demolition Operations.

PART 2 - PRODUCTS - (NOT USED)

PART 3 - EXECUTION

3.1 PROGRESS CLEANING

A. Progress Cleaning – General:
   1. Clean the Site, work areas, and other areas occupied by Contractor not less than weekly. Dispose of waste materials in accordance with the General Conditions, as may be modified by the Supplementary Conditions, and the following:
      a. Comply with NFPA 241 for removing combustible waste materials and debris.
      b. Do not hold non-combustible materials at the Site more than three days if the ambient air temperature is expected to rise above 80 DEGF. When ambient air temperature is less than 80 DEGF, dispose of non-combustible materials within seven days of their generation.
      c. Provide suitable containers for storage of waste materials and debris. Avoid generation of odors and creation of nuisances.
      d. Containerize hazardous and unsanitary waste materials separately from other waste. Mark containers appropriately.

B. Progress Cleaning – Site:
   1. Keep outdoor, dust-generating areas wetted down or otherwise control dust emissions.
   2. Not less than weekly, brush-sweep roadways and paved areas at the Site and adjacent areas used by construction vehicles or otherwise affected by construction activities.

C. Progress Cleaning – Work Areas:
   1. Clean areas where the Work is in progress to maintain an extent of cleanliness necessary for proper execution of the Work and safety of personnel.

2. Remove liquid spills promptly. Where spills may have harmful effects on health, safety, protection of facilities, or the environment, immediately report spills to Owner, Engineer, and authorities having jurisdiction, in accordance with the Contract Documents and Laws and Regulations.
3. Where dust would impair proper execution of or quality of the Work, broom-clean or vacuum entire work area, as necessary.

D. Progress Cleaning – Installed Work:
1. Keep installed Work clean. Clean installed surfaces according to written instructions of manufacturer or fabricator of installed materials and equipment, using only cleaning agents and methods specifically recommended by material or equipment Supplier.
2. If Supplier does not recommend specific cleaning agents or methods, use cleaning agents and methods that are not hazardous to health and property and that will not damage or mar exposed surfaces.

E. Progress Cleaning – Exposed Surfaces:
1. Clean exposed surfaces and protect as necessary to ensure freedom from damage and deterioration until Substantial Completion.

F. Progress Cleaning – Cutting and Patching:
1. Clean areas and spaces where cutting and patching are performed. Completely remove paint, mortar, oils, putty, trailings and cuttings, and similar materials.
2. Comply with Section 01 73 29 - Cutting and Patching, regarding cleaning during and after cutting and patching Work.
3. Thoroughly clean piping, ductwork, conduits, and similar features before applying patching material, paint, or other finishing materials.
4. Restore damaged insulation and coverings on piping, cutwork, and similar items to its pre-construction condition.

G. Waste Disposal:
1. Properly dispose of waste materials (including surplus materials, debris, rubbish, and other waste) off the Site.
2. Do not burn or bury waste materials at the Site.
3. Remove waste material and rubbish from excavations before backfilling.
4. Do not discharge volatile or hazardous substances, such as mineral spirits, oil, or paint thinner, into storm sewers, gutters, sanitary sewers, or other location in the environment. Dispose of such materials in accordance with Laws and Regulations.
5. Do not discharge wastes to surface waters, drainage routes, or groundwater.
6. Contractor is solely responsible for complying with Laws and Regulations regarding storing, transporting, and disposing of waste generated by Contractor's operations or brought to the Site by Contractor.

H. During handling and installation of materials and equipment, clean and protect construction in progress and adjoining materials and equipment already in place. Apply protective covering where necessary or required for protection from damage or deterioration, until Substantial Completion.

I. Clean completed construction as frequently as necessary throughout the construction period.

3.2 CLOSEOUT CLEANING

A. Complete the following prior to requesting inspection for Substantial Completion:
1. Clean and remove from the Site waste material (including rubbish and debris) and other foreign and undesirable items and substances.
2. Sweep broom-clean paved areas suitable for access by vehicles.
3. Remove spills and stains or petroleum, oils, solvents, other chemicals, and other foreign and undesirable deposits.
4. Hose-clean sidewalks and loading areas.
5. Rake grounds that are neither planted nor paved to a smooth, even-textured surface.

6. Surface waterways and drainage routes (including storm sewers, gutters, and ditches) shall be open and clean.
7. Repair pavement, roads, sod, and other areas affected by construction operations and restore to specified condition; if condition is not specified, restore to preconstruction condition.
8. Clean exposed exterior and interior hard-surfaced finishes to dirt-free condition, free of spatter, grease, stains, fingerprints, films, and similar foreign and undesirable substances.
9. Remove waste material and surface dust from limited-access spaces, including equipment vaults, manholes, and similar spaces.
10. Remove non-permanent tags and labels.
11. Surface Finishes:
    a. Touch-up and otherwise repair and restore chipped, scratched, dented or otherwise marred surfaces to specified finish and match adjacent surfaces.
    b. Do not paint over "UL" or similar labels, including mechanical and electrical nameplates.
12. Wipe surfaces of mechanical and electrical equipment, and similar equipment. Remove excess lubrication, paint, and mortar droppings, and other foreign or undesirable substances.
13. Leave the Site clean, and in neat, orderly condition, satisfactory to Owner and Engineer.

B. Complete the following prior to requesting final inspection:
1. After Substantial Completion of all the Work, following completion of items of incomplete or damaged Work ("punch list Work"), clean "punch list Work areas in accordance with Paragraph 3.2.A of this Specifications Section.
2. Remove field offices, Contractor's storage sheds, and remaining stockpiles and clean all such areas in accordance with Paragraph 3.2.B of this Specifications Section, and in accordance with Contract Documents for landscaping and restoration.

END OF SECTION

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SECTION 01 75 00
CHECKOUT AND START-UP PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Administrative and procedural requirements for checkout and startup of equipment, systems, and facilities.

B. Scope:
   1. Contractor shall initially check out, start up, and place equipment and systems installed under the Contract into successful operation, in accordance with the material and equipment manufacturers' written instructions, Suppliers' recommendations at the Site, and the Contract Documents.
   2. Provide the following:
      a. All labor, tools, materials, and equipment required to complete equipment and system checkout and startup.
      b. Chemicals, lubricants, and other required operating fluids necessary for checkout, startup, and initial operation of the Work.
      c. Filters and other temporary or consumable items necessary for checkout, startup, and initial operation of the Work.
      d. Fuel, electricity, water, and other temporary utilities and temporary facilities necessary for checkout and startup of equipment and systems, unless otherwise specified.

C. Related Sections include but are not necessarily limited to:
   1. Section 01 33 04 - Operation and Maintenance Manuals
   2. Section 01 61 03 - Equipment - Basic Requirements.

1.2 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate checkout and startup with other contractors, as necessary.
   2. Do not start up equipment or system(s) for continuous operation until all components of that equipment item or system, including instrumentation and controls, have been tested to the extent practicable and proven to be operable as intended by the Contract Documents.
   3. Subject to the constraints of this Specifications section, Owner will furnish sufficient personnel to assist Contractor in starting up equipment and system(s), but responsibility for proper operation of the Work is Contractor's.
   4. Supplier shall be present during checkout, startup, and initial operation, unless otherwise acceptable to Engineer or otherwise required by the Contract Documents.
   5. Do not start up equipment and system(s), without submitting acceptable preliminary operations and maintenance manuals by Contractor in accordance with the Contract Documents.

B. Scheduling:
   1. Progress Schedule:
      a. Clearly indicate in the Progress Schedule planned and actual dates for checkout, startup, and field quality control activities, including all demonstration testing activities addressed in this Specifications section and elsewhere in the Contract Documents. Separately indicate checkout, startup, and field quality control activities for each equipment item and system.
      b. Perform startup and field quality control activities on the associated, scheduled dates, unless otherwise acceptable to Owner, facility manager, and Engineer.
   2. Restrictions for Scheduling:

a. Checkout of materials, equipment, and systems by Contractor that do not involve or require Owner's or facility manager's personnel may be performed at any time during normal working hours. Where required by the Contract Documents or requested by Engineer, perform checkout in the presence of Engineer or Resident Project Representative (RPR).
b. Startup, including initial operation of materials, equipment, and systems, shall not be initiated on: Monday, Friday, Saturday, Sunday, Owner's holidays, the day immediately prior to a holiday, or the day immediately following a holiday, unless otherwise acceptable to Owner, facility manager, and Engineer.
c. Unless otherwise indicated in the Contract Documents or acceptable to Owner, facility manager, and Engineer, perform all startup during normal working hours of the day shift.
d. To the extent practicable, where extended-duration startup or field quality control activities are required by the Contract, avoid having such activities extend into evening, night, weekend, or holiday hours.
e. Owner reserves the right to require a minimum seven days' notice of rescheduled startup when Contractor cannot perform the associated activities as scheduled.

3. Operation and Maintenance Data:
   a. Comply with Section 01 33 04 - Operation and Maintenance Manuals.
   b. A preliminary copy of all operation and maintenance manuals shall be received by Engineer prior to the start of the demonstration period "OAT".

1.3 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Do not start up equipment or systems or place into initial operation until required operating permits are obtained from authorities having jurisdiction.
   2. Where Owner (with or without assistance of Engineer) has applied for and obtained initial approvals or permits necessary for operation, Contractor shall furnish information and assistance to Owner or Engineer for Owner to secure final approvals from authorities having jurisdiction for required operating permits.

1.4 SUBMITTALS

A. Informational Submittals: Submit the following:
   1. Progress Schedules indicating dates for checkout, startup, and field quality control activates.
   2. Completed checkout and startup log required in Paragraph 3.2.C of this Specifications section.
   3. Manufacturer's installation check letters (also known as Manufacturer's Field Services Report) required in Paragraph 3.2.C of this Specifications section.
   4. Instrumentation Supplier's Instrumentation Installation Certificate, required in Paragraph 3.2.C of this Specifications section.
   5. Letter verifying completion of all pre-demonstration startup activities, required in Paragraph 3.2.C of this Specifications section.
   6. Report of data collected during each required Demonstration Period.
   7. Qualifications Statements:
      a. Qualifications, including resume' and copy of license, of Contractor-retained licensed operator.

PART 2 - PRODUCTS - (NOT USED)

PART 3 - EXECUTION

3.1 CHECKOUT AND STARTUP – GENERAL

A. Pre-Demonstration Period:

a. Obtain Engineer's approval or acceptance (as applicable) of Submittals required prior to checkout and startup, including all Shop Drawings, Samples, source quality control (shop testing) Submittals, preliminary operation and maintenance manuals, and other Submittals required by the Contract Documents, other than Submittals that cannot be furnished until after startup.
b. Complete the Work to a point ready for checkout and startup, including operation available in all manual, automatic, and other modes.
c. Checkout and initial field quality control activities that can be performed prior to startup of the equipment or system.
d. Startup of the associated Work.
e. Field quality control activities for the subject Work as indicated elsewhere in the Specifications and other Contract Documents, other than this section.
f. Training of operations and maintenance personnel.

3.2 PRE-DEMONSTRATION PERIOD

A. Prior to the Pre-Demonstration Period, complete the Work to the point where it is ready for checkout and startup.

B. Checkout.
1. Comply with Section 01 61 03 - Equipment - Basic Requirements, including provisions concerning installation checks
2. Coordinate with charger installer for hand off of electrical installation to charger installer.

C. Startup:
1. Comply with requirements for startup of materials, equipment, and systems indicated in the associated Specification sections and elsewhere in the Contract Documents.
2. Prepare the Work so it will operate properly and safely and be ready to demonstrate functional integrity during the Demonstration Period.
3. Procedures include but are not necessarily limited to the following:
   a. Test or check and correct deficiencies of:
      1) Power, control, and monitoring circuits for continuity prior to connection to power source.
      2) Voltage of all circuits.
      3) Phase sequence.
      4) Cleanliness of connecting piping systems.
      5) Tagging and identification systems.
      6) Proper connections, alignment, calibration and adjustment.
   b. Calibrate safety equipment.
4. Obtain Suppliers' certifications of the installed and operational Work, without restrictions or conditions, and submit to Engineer:
   a. Manufacturer's installation check letters (sometimes referred to as Manufacturer's Field Services Report).
   b. Instrumentation Supplier's Instrumentation Installation Certificate.

END OF SECTION

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DIVISION 03

CONCRETE

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SECTION 03 00 05
CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Cast-in-place concrete and grout.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Concrete Institute (ACI):
      a. 117, Specification for Tolerances for Concrete Construction and Materials.
      b. 211.1, Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete.
      c. 212.3R, Chemical Admixtures for Concrete.
      d. 304R, Guide for Measuring, Mixing, Transporting, and Placing Concrete.
      e. 304.2R, Placing Concrete by Pumping Methods.
      f. 305.1, Hot Weather Concreting.
      g. 306.1, Cold Weather Concreting.
      h. 318, Building Code Requirements for Structural Concrete.
      i. 347, Guide to Formwork for Concrete.
      j. CT-13, Concrete Terminology.
   2. ASTM International (ASTM):
      a. A82, Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
      b. A185, Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
      c. A615, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
      d. A1064, Standard Specification for Steel Wire and Welded Wire Replacement, Plain and Deformed, for Concrete.
      e. C31, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
      f. C33, Standard Specification for Concrete Aggregates.
      g. C39, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
      h. C94/C94M, Standard Specification for Ready-Mixed Concrete.
      i. C138, Standard Method of Test for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.
      j. C143, Standard Test Method for Slump of Hydraulic Cement Concrete.
      k. C150, Standard Specification for Portland Cement.
      l. C172, Standard Practice for Sampling Freshly Mixed Concrete.
      m. C173, Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
      n. C231, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
      o. C260, Standard Specification for Air-Entraining Admixtures for Concrete.
      p. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
      q. C494, Standard Specification for Chemical Admixtures for Concrete.

r. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
s. C1293, Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction.
t. C1315, Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete.
u. D882, Standard Test Method for Tensile Properties of Thin Plastic Sheeting.
v. D994, Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
w. D1056, Standard Specification for Flexible Cellular Materials-Sponge or Expanded Rubber.
x. D1709, Standard Test Methods for Impact Resistance of Plastic Film by the Free-Falling Dart Method.
y. D1751, Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
z. E96, Standard Test Methods for Water Vapor Transmission of Materials.
aa. E329, Standard Specification for Agencies Engaged in Construction Inspection and/or Testing.

3. Corps of Engineers (COE):
   a. CRD-C621, Standard Specification for Packaged, Dry, Hydraulic-Cement Grout (Nonshrink).
4. National Ready Mixed Concrete Association (NRMCA).

B. Quality Control:
1. Concrete testing agency:
   a. Contractor to employ and pay for services of a testing laboratory to:
   b. Perform materials evaluation.
   c. Perform testing of concrete placed during construction.
   d. Concrete testing agency to meet requirements of ASTM E329.
2. Adjust concrete mix designs when material characteristics, job conditions, weather, strength test results or other circumstances warrant.

C. Qualifications:
1. Ready mixed concrete batch plant certified by NRMCA.

1.3 DEFINITIONS

A. Per ACI CT-13 except as modified herein:
1. Concrete fill: Non-structural concrete.
2. Concrete Testing Agency: Testing agency employed to perform materials evaluation, design of concrete mixes or testing of concrete placed during construction.
3. Exposed concrete: Exposed to view after construction is complete.
4. Indicated: Indicated by Contract Documents.
5. Nonexposed concrete: Not exposed to view after construction is complete.
6. Required: Required by Contract Documents.
7. Specified strength: Specified compressive strength at 28 days.
8. Submitted: Submitted to Engineer.

1.4 SUBMITTALS

A. Shop Drawings:
1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
2. Concrete mix designs proposed for use.
   a. Concrete mix design submittal to include the following information:
      1) Sieve analysis and source of fine and coarse aggregates.
      2) Test for aggregate organic impurities.
      3) Test for deleterious aggregate per ASTM C1293.

4) Proportioning of all materials.
5) Type of cement with mill certificate for cement.
6) Type of fly ash with certificate of conformance to specification requirements.
7) Slump.
8) Air content.
9) Brand, type, ASTM designation, and quantity of each admixture proposed for use.
10) 28-day cylinder compressive test results of trial mixes per ACI 318 and as indicated herein.

3. Product technical data including:
   a. Acknowledgement that products submitted meet requirements of standards referenced.
   b. Manufacturer's installation instructions.
   c. Manufacturers and types:
      1) Joint fillers.
      2) Curing agents.
      3) Chemical sealer.
      4) Bonding and patching mortar.
      5) Construction joint bonding adhesive.
      6) Nonshrink grout with cure/seal compound.
4. Reinforcing steel:
   a. Show grade, sizes, number, configuration, spacing, location and all fabrication and placement details.
   b. In sufficient detail to permit installation of reinforcing without having to make reference to Contract Drawings.
   c. Obtain approval of Shop Drawings by Engineer before fabrication.
   d. Mill certificates.
5. Certifications:
   a. Certification of standard deviation value in psi for ready mix plant supplying the concrete.
   b. Certification that the material and sources submitted in the mix design will be used in the concrete for this project.
6. Test reports:
   a. Cement mill reports for all cement to be supplied.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Storage of Material:
1. Cement and pozzolan:
   a. Store in moistureproof, weathertight enclosures.
   b. Do not use if caked or lumpy.
2. Aggregate:
   a. Store to prevent segregation and contamination with other sizes or foreign materials.
   b. Obtain samples for testing from aggregates at point of batching.
   c. Do not use frozen or partially frozen aggregates.
   d. Do not use bottom 6 IN of stockpiles in contact with ground.
   e. Allow sand to drain until moisture content is uniform prior to use.
3. Admixtures:
   a. Protect from contamination, evaporation, freezing, or damage.
   b. Maintain within temperature range recommended by manufacturer.
   c. Completely mix solutions and suspensions prior to use.
4. Reinforcing steel: Support and store all rebars above ground.

B. Delivery:
1. Concrete:
   a. Prepare a delivery ticket for each load for ready-mixed concrete.
   b. Truck operator shall hand ticket to Owner's Representative at the time of delivery.
   c. Ticket to show:
      1) Mix identification mark.

2) Quantity delivered.
3) Amount of each material in batch.
4) Outdoor temp in the shade.
5) Time at which cement was added.
6) Numerical sequence of the delivery.
7) Amount of water added.

2. Reinforcing steel:
   a. Ship to jobsite with attached plastic or metal tags with permanent mark numbers.
   b. Mark numbers to match Shop Drawing mark number.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following products and manufacturers are acceptable:
   1. Form coating:
      a. Richmond "Rich Cote."
      b. Industrial Lubricants "Nox-Crete Form Coating."
      c. Euclid Chemical "Kurez DR VOX."

2.2 MATERIALS

A. Portland Cement: Conform to ASTM C150.

B. Admixtures:
   1. Air entraining admixtures: ASTM C260.
   2. Water reducing, retarding, and accelerating admixtures:
      a. ASTM C494 Type A through E.
      b. Conform to provisions of ACI 212.3R.
      c. Do not use retarding or accelerating admixtures unless specifically approved in writing by Engineer and at no cost to Owner.
      d. Follow manufacturer's instructions.
      e. Use chloride free admixtures only.
   3. Maximum total water soluble chloride ion content contributed from all ingredients of concrete including water, aggregates, cementitious materials and admixtures by weight percent of cement:
      a. 0.06 prestressed concrete.
      b. 0.10 all concrete.
   4. Do not use calcium chloride.
   5. Pozzolanic admixtures: ASTM C618.
   6. Provide admixtures of same type, manufacturer and quantity as used in establishing required concrete proportions in the mix design.

C. Water: Potable, clean, free of oils, acids and organic matter.

D. Aggregates:
   1. Normal weight concrete: ASTM C33, except as modified below.
   2. Fine aggregate:
      a. Clean natural sand.
      b. No manufactured or artificial sand.
   3. Coarse aggregate:
      a. Crushed rock, natural gravel, or other inert granular material.
      b. Maximum amount of clay or shale particles: 1 PCT.
   4. Gradation of coarse aggregate:
      a. Lean concrete and concrete topping: Size #7.
      b. All other concrete: Size #57 or #67.
   5. Use only washed aggregates.

6. Pozzolan or other additives shall not be used to compensate for alkali reactivity of aggregates.
7. Coarse aggregate for lightweight concrete: ASTM C330.
    a. Maximum size: 3/4 IN.

E. Maximum total chloride ion content for concrete mix including all ingredients measured as a weight percent of cement:
1. 0.10 for all cast-in-place concrete.
2. 0.06 for precast concrete.
3. Do not use calcium chloride.

F. Concrete Grout:
1. Nonshrink, nonmetallic grout:
    a. Nonmetallic, noncorrosive, nonstaining, premixed with only water to be added.
    b. Grout to produce a positive but controlled expansion.
    c. Mass expansion not to be created by gas liberation.
    d. Minimum compressive strength of nonshrink grout at 28 days: 6500 PSI.
    e. In accordance with COE CRD-C621.
2. Epoxy grout:
    a. 3-component epoxy resin system.
        1) Two liquid epoxy components.
        2) One inert aggregate filler component.
    b. Each component packaged separately for mixing at jobsite.

G. Reinforcing Steel:
1. Reinforcing bars: ASTM A615, Grade 60.
2. Welded wire reinforcement:
    a. ASTM A185 or ASTM A1064.
    b. Minimum yield strength: 60,000 PSI.
3. Column spirals: ASTM A82 or ASTM A1064.

H. Forms:
1. Prefabricated or job built.
2. Wood forms:
    a. 5/8 or 3/4 IN 5-ply structural plywood of concrete form grade.
    b. Built-in-place or prefabricated type panel.
3. Metal forms:
    a. Metal forms may be used except for aluminum in contact with concrete.
    b. Forms to be tight to prevent leakage, free of rust and straight without dents to provide members of uniform thickness.
4. Chamfer strips: Clear white pine, surface against concrete planed.

I. Form Ties:
1. Commercially fabricated for use in form construction.
    a. Field fabricated ties are unacceptable.
2. Constructed so that ends or end fasteners can be removed without causing spalling at surfaces of the concrete.
3. 3/4 IN minimum diameter cones on both ends.
4. Embedded portion of ties to be not less than 1-1/2 IN from face of concrete after ends have been removed.
5. Cone size:
    a. 3/4 IN minimum diameter cones on both ends.
    b. Depth of cone not to exceed the concrete reinforcing cover.
6. Form release: Nonstaining and shall not prevent bonding of future finishes to concrete surface.

J. Chairs, Runners, Bolsters, Spacers, and Hangers:
1. Stainless steel, epoxy coated, or plastic coated metal.

a. Plastic coated: Rebar support tips in contact with the forms only.

K. Expansion Joint Filler:
1. In contact with water or sewage:
a. Closed cell neoprene.
b. ASTM D1056, Class SC (oil resistant and medium swell) of 2 to 5 PSI compression deflection (Grade SCE41).
2. Exterior driveways, curbs and sidewalks:
a. Asphalt expansion joint filler.
b. ASTM D994.
3. Other use:
a. Fiber expansion joint filler.
b. ASTM D1751.

2.3 CONCRETE MIXES

A. General:
1. All concrete to be ready mixed concrete conforming to ASTM C94/C94M.
2. Provide concrete of specified quality capable of being placed without segregation and, when cured, of developing all properties required.
3. All concrete to be normal weight concrete.
4. Provide pozzolan content for all cast-in-place construction.

B. Strength:
1. Provide specified strength and type of concrete for each use in structure(s) as follows:

TYPE	WEIGHT	SPECIFIED STRENGTH*
All other general use concrete	Normal weight	4000 PSI

* Minimum 28-day compressive strength.

C. Air Entrainment:
1. Provide air entrainment in all concrete resulting in a total air content percent by volume as follows:

MAX AGGREGATE SIZE	TOTAL AIR CONTENT PERCENT
1 IN or 3/4 IN	6 ±1-1/2
<3/4 IN	6-1/2 ±1-1/2

2. Air content to be measured in accordance with ASTM C231, ASTM C173, or ASTM C138.

D. Slump - 4 IN maximum, 1 IN minimum:
1. Measured at point of discharge of the concrete into the concrete construction member.
2. 8 IN maximum after addition of superplasticizer (if used).
3. Concrete of lower than minimum slump may be used provided it can be properly placed and consolidated.
4. Pumped concrete:
a. Provide additional water at batch plant to allow for slump loss due to pumping.
b. Provide only enough additional water so that slump of concrete at discharge end of pump hose does not exceed maximum slump specified and the maximum specified water-cement ratio is not exceeded.
5. Slump may be adjusted in the field through the use of water reducers.
a. Coordinate dosage and mixing requirements with concrete supplier.
6. Determine slump per ASTM C143.

E. Selection of Proportions:
1. General:

a. Proportion ingredients to:
    1) Produce proper workability, durability, strength, and other required properties.
    2) Prevent segregation and collection of excessive free water on surface.
2. Minimum cement contents and maximum water cement ratios for concrete to be as follows:

SPECIFIED STRENGTH	TARGET CEMENT, MAXIMUM AGGREGATE SIZE			MAXIMUM WATER CEMENT RATIO BY WEIGHT
	1/2 IN	3/4 IN	1 IN	
4000	564	564	564	0.45
4500	611	611	--	0.42

3. Fly ash:
    a. For cast-in-pace concrete only, a maximum of 25 PCT by weight of Portland cement content per cubic yard may be replaced with fly ash at rate of 1 LB fly ash for 1 LB of cement.
    b. When fly ash is used, the water to cementitious materials ratio shall not exceed the maximum value specified herein.
4. Concrete mix proportioning methods for normal weight concrete:
    a. Proportion mixture to provide desired characteristics using one of methods described below:
        1) Method 1 (Trial Mix):
            a) Per ACI 318, Chapter 5, except as modified herein.
            b) Air content within range specified above.
            c) Record and report temperature of trial mixes.
            d) Proportion trial mixes per ACI 211.1.
        2) Method 2 (Field Experience):
            a) Per ACI 318, Chapter 5, except as modified herein:
            b) Field test records must be acceptable to Engineer to use this method.
            c) Test records shall represent materials, proportions and conditions similar to those specified.
5. Required average strength to exceed the specified 28-day compressive strength by the amount determined or calculated in accordance with the requirements of Chapter 5 of ACI 318 using the standard deviation of the proposed concrete production facility.

PART 3 - EXECUTION

3.1 FORMING AND PLACING CONCRETE

A. Formwork:
1. Contractor is responsible for design and erection of formwork.
2. Construct formwork so that concrete members and structures are of correct size, shape, alignment, elevation and position.
    a. Allowable tolerances: As recommended in ACI 347.
3. Provide slabs and beams of minimum indicated depth when sloping foundation base slabs or elevated floor slabs to drains.
    a. For slabs on grade, slope top of subgrade to provide floor slabs of minimum uniform indicated depth.
    b. Do not place floor drains through beams.
4. Openings:
    a. Provide openings in formwork to accommodate work of other trades.
    b. Accurately place and securely support items built into forms.
5. Chamfer strips: Place 3/4 IN chamfer strips in forms to produce 3/4 IN wide beveled edges on permanently exposed corners of members.

6. Clean and adjust forms prior to concrete placement.
7. Tighten forms to prevent mortar leakage.
8. Coat form surfaces with form release agents prior to placing reinforcing bars in forms.

B. Reinforcement:
   1. Position, support and secure reinforcement against displacement.
   2. Locate and support with chairs, runners, bolsters, spacers and hangers, as required.
   3. Set wire ties so ends do not touch forms and are directed into concrete, not toward exposed concrete surfaces.
   4. Lap splice lengths: ACI 318 Class B top bar tension splices unless indicated otherwise on the Drawings.
   5. Extend reinforcement to within 2 IN of concrete perimeter edges.
      a. If perimeter edge is earth formed, extend reinforcement to within 3 IN of the edge.
   6. Minimum concrete protective covering for reinforcement: As shown on Drawings.
   7. Do not weld reinforcing bars.
   8. Welded wire reinforcement:
      a. Install welded wire reinforcement in maximum practical sizes.
      b. Splice sides and ends with a splice lap length measured between outermost cross wires of each fabric sheet not less than:
         1) One spacing of cross wires plus 2 IN.
         2) 1.5 x development length.
         3) 6 IN.
      c. Development length: ACI 318 basic development length for the specified fabric yield strength.

C. Placing Concrete:
   1. Place concrete in compliance with ACI 304R and ACI 304.2R.
   2. Place in a continuous operation within planned joints or sections.
   3. Begin placement when work of other trades affecting concrete is completed.
   4. Place concrete by methods which prevent aggregate segregation.
   5. Do not allow concrete to free fall more than 4 FT.
   6. Where free fall of concrete will exceed 4 FT, place concrete by means of tremie pipe or chute.

D. Consolidation: Consolidate all concrete using mechanical vibrators supplemented with hand rodding and tamping, so that concrete is worked around reinforcement and embedded items into all parts of forms.

E. Protection:
   1. Protect concrete from physical damage or reduced strength due to weather extremes.
   2. In cold weather comply with ACI 306.1 except as modified herein.
      a. Do not place concrete on frozen ground or in contact with forms or reinforcing bars coated with frost, ice or snow.
      b. Do not place heated concrete that is warmer than 80 DEGF.
      c. If freezing temperatures are expected during curing, maintain the concrete temperature at or above 50 DEGF for seven days or 70 DEGF for 3 days.
      d. Do not allow concrete to cool suddenly.
   3. In hot weather comply with ACI 305.1 except as modified herein.
      a. At air temperature of 90 DEGF and above, keep concrete as cool as possible during placement and curing.
      b. Do not allow concrete temperature to exceed 90 DEGF at placement.
      c. Prevent plastic shrinkage cracking due to rapid evaporation of moisture.
      d. Do not place concrete when the actual or anticipated evaporation rate equals or exceeds 0.2 LBS/SF/HR as determined from ACI 305.1, Figure 2.1.5.

F. Curing:

1. Begin curing concrete as soon as free water has disappeared from exposed surfaces.
2. Cure concrete by use of moisture retaining cover, burlap kept continuously wet or by membrane curing compound.
3. Provide protection as required to prevent damage to concrete and to prevent moisture loss from concrete during curing period.
4. Provide curing for minimum of seven days.
5. Form materials left in place may be considered as curing materials for surfaces in contact with the form materials except in periods of hot weather.
6. In hot weather follow curing procedures outlined in ACI 305.1.
7. In cold weather follow curing procedures outlined in ACI 306.1.
8. Curing vertical surfaces with a curing compound:
    a. Cover vertical surfaces with a minimum of two coats of the curing compound.
    b. Allow the preceding coat to completely dry prior to applying the next coat.
    c. Apply the first coat of curing compound immediately after form removal.
    d. Vertical surface at the time of receiving the first coat shall be damp with no free water on the surface.
    e. A vertical surface is defined as any surface steeper than 1 vertical to 4 horizontal.

G. Form Removal:
1. Remove forms after concrete has hardened sufficiently to resist damage from removal operations or lack of support.
2. Where no reshoring is planned, leave forms and shoring used to support concrete until it has reached its specified 28-day compressive strength.

3.2 CONCRETE FINISHES

A. Tolerances:
1. Class A: 1/8 IN in 10 FT.
2. Class B: 1/4 IN in 10 FT.

B. Surfaces Exposed to View:
1. Provide a smooth finish for exposed concrete surfaces and surfaces that are:
    a. To be covered with a coating or covering material applied directly to concrete.
2. Remove fins and projections, and patch voids, air pockets, and honeycomb areas with cement grout.
3. Cementitious concrete coating:
    a. Form facing material shall produce a smooth, hard, uniform texture.
        1) Use forms specified for surfaces exposed to view.
    b. Prepare the surface in accordance with manufactures printed installation instructions.
    c. Brush on coating to entire surface.
        1) As a mixing liquid for the coating, use bonding agent and water mixture as recommended by the manufacture.
        2) Apply two (2) coats at 2 LB/SQYD per coat.
    d. When second coat is set, float to a uniform texture with a sponge coat.
    e. Provide this finish at the following locations:
        1) Walls, columns, exposed to view.

C. Grout Cleaned Finish:
1. Mix one part Portland cement and 1-1/2 parts fine sand with sufficient bonding agent/water mixture to produce a grout with the consistency of thick paint.
    a. White Portland cement shall be substituted for gray Portland cement to produce a color that matches color of surrounding concrete as determined by trial patch for areas not to be painted.
2. Wet surface of concrete to prevent absorption of water by grout and uniformly apply grout with brushes or spray gun.
3. Immediately scrub the surface with a cork float or stone to coat and fill air bubbles and holes.

4. While grout is still plastic, remove all excess grout by working surface with rubber float, sack or other approved means.
5. After the surface whitens from drying, rub vigorously with clean burlap.
6. Keep final finish damp for a minimum of 36 HRS after final rubbing.

D. Broom Finish: Immediately after concrete has received a float finish as specified, give it a transverse scored texture by drawing a broom across surface.

3.3 GROUT

A. Preparation:
   1. Nonshrinking, nonmetallic grout:
      a. Clean concrete surface to receive grout.
      b. Saturate concrete with water for 24 HRS prior to grouting.
   2. Rock anchors:
      a. Clean rock anchors of all loose material.
      b. Orient hook or bends in anchor bars to clear anchor bolts, reinforcements, and other embedments to be installed later.
   3. Epoxy grout: Apply only to clean, dry, sound surface.

B. Application:
   1. Nonshrinking, nonmetallic grout:
      a. Mix in a mechanical mixer.
      b. Use no more water than necessary to produce flowable grout.
      c. Place in accordance with manufacturer's instructions.
      d. Completely fill all spaces and cavities below the bottom of baseplates.
      e. Provide forms where baseplates and bedplates do not confine grout.
      f. Where exposed to view, finish grout edges smooth.
      g. Except where a slope is indicated on Drawings, finish edges flush at the baseplate, bedplate, member, or piece of equipment.
      h. Protect against rapid moisture loss by covering with wet rags or polyethylene sheets.
      i. Wet cure grout for seven days, minimum.
   2. Epoxy grout:
      a. Mix and place in accordance with manufacturer's instructions.
      b. Completely fill all cavities and spaces around dowels and anchors without voids.
      c. Obtain manufacturer's field technical assistance as required to ensure proper placement.

3.4 FIELD QUALITY CONTROL

A. Owner will employ and pay for services of a concrete testing laboratory to perform testing of concrete placed during construction.
   1. Contractor to cooperate with Owner in obtaining and testing samples.

B. Tests During Construction:
   1. Strength test:
      a. For each strength test, mold and cure cylinders from each sample in accordance with ASTM C31.
         1) Cylinder size: Per ASTM C31.
            a) 4 IN cylinders may not be used for concrete mixes with concrete aggregate size larger than 1 IN.
         2) Quantity:
            a) 6 IN DIA by 12 IN high: Four cylinders.
            b) 4 IN DIA by 8 IN high: Six cylinders.
      b. Field cure one (1) cylinder for the seven day test.
         1) Laboratory cure the remaining.
      c. Test cylinders in accordance with ASTM C39.
         1) 6 IN DIA cylinders:
            a) Test two cylinders at 28 days for strength test result and the one field cured sample at seven days for information.

b) Hold remaining cylinder in reserve.
2) 4 IN DIA cylinders:
a) Test three cylinders at 28 days for strength test result and the one field cured cylinder at seven days for information.
b) Hold remaining cylinders in reserve.
d. Strength test result:
1) Average of strengths of two 6 IN DIA cylinders or three 4 IN DIA cylinders from the same sample tested at 28 days.
2) If one cylinder in a test manifests evidence of improper sampling, molding, handling, curing, or testing, discard and test reserve cylinder(s); average strength of remaining cylinders shall be considered strength test result.
3) Should all cylinders in any test show any of above defects, discard entire test.
e. Frequency of tests:
a) One strength test to be taken not less than once a day, nor less than once for each 60 CUYD or fraction thereof placed in any one day.
b) Once for each 5000 SQFT of slab or wall surface area placed each day.
c) If total volume of concrete on Project is such that frequency of testing required in above paragraph will provide less than five strength tests for each concrete mix, tests shall then be made from at least five randomly selected batches or from each batch if fewer than five batches are provided.
2. Slump test:
a. Per ASTM C143.
b. Determined for each strength test sample.
c. Additional slump tests may be taken.
3. Air content:
a. Per ASTM C231, ASTM C173, and ASTM C138.
b. Determined for each strength test sample.
4. Temperature: Determined for each strength test sample.

C. Evaluation of Tests:
1. Strength test results:
a. Average of 28-day strength of two cylinders from each sample.
1) If one cylinder manifests evidence of improper sampling, molding, handling, curing or testing, strength of remaining cylinder will be test result.
2) If both cylinders show any of above defects, test will be discarded.

D. Acceptance of Concrete:
1. Strength level of each type of concrete shall be considered satisfactory if both of the following requirements are met:
a. Average of all sets of three consecutive strength tests equals or exceeds the required specified 28-day compressive strength.
b. No individual strength test falls below the required specified 28-day compressive strength by more than 500 PSI.
2. If tests fail to indicate satisfactory strength level, perform additional tests and/or corrective measures as directed by Engineer.
a. Perform additional tests and/or corrective measures at no additional cost to Owner.

E. Concrete tolerances per ACI 117.

3.5 SCHEDULES

A. Form Types:
1. Surfaces exposed to view:
a. Prefabricated or job-built wood forms.
b. Laid out in a regular and uniform pattern with long dimensions vertical and joints aligned.
c. Produce finished surfaces free from offsets, ridges, waves, and concave or convex areas.

d. Construct forms sufficiently tight to prevent leakage of mortar.

2. Surfaces normally submerged or not normally exposed to view: Wood or steel forms sufficiently tight to prevent leakage of mortar.
3. Other types of forms may be used:
   a. For surfaces not restricted to plywood or lined forms.
   b. As backing for form lining.

B. Grout:
1. Nonshrinking, nonmetallic grout: General use.

C. Concrete:
1. Normal weight concrete: All concrete.
2. General use concrete: All other locations.

D. Concrete Finishes:
1. Slab finishes:
   a. Use following finishes as applicable, unless otherwise indicated:
      1) Floated finish: Surfaces intended to receive roofing, concrete topping, lean concrete, concrete fill and waterproofing.
      2) Troweled finish: Interior floor slabs, exposed roof slabs and base slabs of structures, equipment bases, and column bases.
      3) Broom finish: Sidewalks, docks, concrete stairs, and ramps.

END OF SECTION

SECTION 03 31 30
CONCRETE, MATERIALS AND PROPORTIONING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Concrete materials, strengths and proportioning for concrete work.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Section 03 00 05 - Concrete.
   4. Section 03 31 31 - Concrete Mixing, Placing, Jointing, and Curing.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Concrete Institute (ACI):
      a. CT-13, Concrete Terminology.
      b. 211.1, Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete.
      c. 212.3R, Chemical Admixtures for Concrete.
      d. 232.2R, Use of Fly Ash in Concrete.
   2. ASTM International (ASTM):
      a. C33, Standard Specification for Concrete Aggregates.
      b. C39, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
      c. C94/C94M, Standard Specification for Ready-Mixed Concrete.
      d. C150, Standard Specification for Portland Cement.
      e. C157, Standard Test Method for Length Change of Hardened Hydraulic-Cement, Mortar, and Concrete.
      f. C192, Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory.
      g. C260, Standard Specification for Air-Entraining Admixtures for Concrete.
      h. C227, Standard Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method).
      i. C494, Standard Specification for Chemical Admixtures for Concrete.
      j. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
      k. C1107, Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink).
      l. C1116, Standard Specification for Fiber-Reinforced Concrete.
      m. C1260, Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method).
      n. C1293, Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction.
      o. C1399, Standard Test Method for Obtaining Average Residual-Strength of Fiber-Reinforced Concrete.
      p. C1567, Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method).
      q. C1609, Standard Test Method for Flexural Performance of Fiber-Reinforced Concrete (Using Beam With Third-Point Loading).
   3. Steel Deck Institute (SDI):

a. 31, Design Manual for Composite Decks, Form Decks and Roof Decks.

1.3 DEFINITIONS

A. Words and terms used in these Specifications are defined in ACI CT-13.

B. Supplementary Cementitious Materials (SCM): Fly ash, silica fume and ground granulated blast furnace slag.

1.4 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data including:
      a. Acknowledgement that products submitted meet requirements of standards referenced.
      b. Manufacturer's instructions.
      c. Concrete mix designs as required by Specification Section 03 00 05.
      d. Manufacturer and type of proposed admixtures.
      e. Manufacturer and type of proposed non-shrink grout and grout cure/seal compound.
   3. Certifications:
      a. Certification of standard deviation value in psi for ready mix plant supplying the concrete.
      b. Certification that the SCM meet the quality requirements stated in this Specification Section, and SCM supplier's certified test reports for each shipment of SCM delivered to concrete supplier.
      c. Certification that the class of coarse aggregate meets the requirements of ASTM C33 for type and location of concrete construction.
      d. Certification of aggregate gradation.
      e. Certification of coarse aggregate impurities as relates to alkali-silica reactivity per ASTM C33, Appendix X.
      f. Certification of shrinkage test results.
   4. Test reports:
      a. Cement and SCM mill reports for all cement to be supplied.
      b. Provide test results for alkali-silica reactive impurities on coarse aggregates per referenced ASTM standards.

1.5 DELIVERY, STORAGE AND HANDLING

A. Storage of Materials:
   1. Store cement and SCM in weathertight buildings, bins, or silos which will exclude moisture and contaminants.
   2. Arrange aggregate stockpiles and use in a manner to avoid excessive segregation and to prevent contamination with other materials or with other sizes of like aggregates.
   3. Allow natural sand to drain until it has reached a relatively uniform moisture content before use.
   4. Do not use frozen or partially frozen aggregates.
   5. Do not use bottom 6 IN layer of stockpiled material in contact with ground.
   6. Store admixtures in such a manner as to avoid contamination, evaporation, or damage.
      a. For those used in form of suspensions or non-stable solutions, provide agitating equipment to assure thorough distribution of ingredients.
      b. Protect liquid admixtures from freezing and temperature changes which would adversely affect their characteristics and performance.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the manufacturers are acceptable:

1. Synthetic fibers:
    a. GCP Applied Technologies, Inc.
    b. BASF Corporation.
    c. Euclid Chemical Company.
    d. Propex Concrete Systems.
    e. Fibermesh.
    f. Sika Corporation.
    g. PGI Performance Concrete Fibers.

B. No like, equivalent or "or-equal" item is permitted.

C. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 MATERIALS

A. Cement:
1. ASTM C150, Type I.
2. Cement type used shall correspond to that upon which selection of concrete proportions was based in the mix design.

B. SCM:
1. Fly Ash:
    a. ASTM C618, Class F or Class C.
    b. Non-staining.
    c. Suited to provide hardened concrete of uniform light gray color.
    d. Compatible with other concrete ingredients and having no deleterious effects on the hardened concrete.
    e. Produced by source approved by the State Highway Department in the state where the Project is located for use in concrete for bridges.
    f. Evaluate and use in accordance with ACI 232.2R.
2. Cement and SCM type used shall correspond to that upon which selection of concrete proportions was based in the mix design.

C. Admixtures:
1. Air entraining: ASTM C260.
2. Water reducing, retarding, and accelerating: Conform to ASTM C494, Types A through E, and provisions of ACI 212.3R.
3. High range water reducers (superplasticizers): Conform to ASTM C494, Types F or G.
4. All concrete mixes require the use of water reducers to maintain the specified water-to-cement ratios without additional cement.
5. SCM: Per above.
6. Admixtures to be chloride free.
    a. Do not use calcium chloride.
7. Provide admixtures of same type, manufacturer and quantity as used in establishing required concrete proportions in the mix design.
8. Provide admixtures certified by manufacturer to be compatible with other admixtures.
9. Shrinkage reducing admixtures:
    a. Admixture used to reduce the shrinkage of Portland Cement concrete.
    b. Utilize at dosage necessary to help achieve required shrinkage value stated herein.
    c. Similar to:
        1) Eclipse 4500 by GCP Applied Technologies, Inc.
        2) Conex by Euclid Chemical Co.
        3) MasterLife SRA 20 or MasterLife CRA 007 by BASF Corporation.

D. Macrosynthetic Fibers:
1. Conform to ASTM C1116.
2. Dosage to obtain a minimum average residual strength at a net deflection of L/150: 170 PSI in accordance with ASTM C1609 and ASTM C1399.
3. Acceptable manufacturers:

a. MasterFiber MAC Series by BASF Corporation.
b. Strux 90/40 by GCP Applied Technologies, Inc.
c. Tuf-Strand SF by Euclid Chemical Company.

E. Microsynthetic Fibers:
1. Conform to ASTM C1116.
2. Minimum average residual strength at a net deflection of L/150: 170 PSI in accordance with ASTM C1609.
3. Acceptable manufacturers:
a. BASF Corporation; MasterFiber F or M Series.
b. Fiberstrand by Euclid Chemical Company.
c. Gilco Fibers by GCP Applied Technologies, Inc.

F. Aggregates for Normal Weight Concrete:
1. ASTM C33.
2. Fine and coarse aggregates to be regarded as separate ingredients.
3. Coarse aggregate:
a. Use only washed aggregates.
b. Coarse aggregate sieve analysis:
1) Per Table 1 IN the PART 2 MIXES Article.
4. Fine aggregates to be natural, not manufactured.
5. Do not use aggregates that may be deleteriously reactive when combined with alkalis in cement.
a. Evaluate proposed aggregates for potential deleterious expansion due to alkali silica reactivity per ASTM C33 (Appendix X), ASTM C227, ASTM C1260, ASTM 1293, or ASTM C1567.

G. Maximum total chloride ion content for concrete mix including all ingredients measured as a weight percent of cement in accordance with ASTM C1218:
1. Prestressed concrete: 0.06.
2. All other concrete: 0.10.

H. Sand Cement Grout (referred to as "Grout" on the Drawings):
1. Approximately three parts sand, one part Portland cement, 6 ±1 PCT entrained air and water to produce a slump which allows grout to completely fill required areas and surround adjacent reinforcing.
a. Provide sand in accordance with requirements for fine aggregate for concrete.
2. Minimum 28 day compressive strength:
a. 3000 PSI.
b. Shall be at least strength of parent concrete when used at construction joints.

I. See Specification Section 03 31 31 for Grout Schedule of use.

2.3 MIXES

A. General:
1. Provide concrete capable of being placed without aggregate segregation and, when cured, of developing all properties specified.
2. Ready-mixed concrete shall conform to ASTM C94/C94M.
3. All concrete to be normal weight concrete, weighing approximately 145 to 150 LBS per cubic foot at 28 days after placement.

B. Concrete Mixes: Refer to Table 1 below.

C. Air Entrainment:
1. Provide air entrainment in concrete resulting in a total air content percent by volume per Table 1 below.
a. Adjust dosage rate as necessary to compensate for shrinkage reducing admixtures.

D. Slump:

1. Measure slump at point of discharge into concrete members.
2. Walls and columns:
    a. 8 IN maximum, 4 IN minimum measured at the point of discharge into the concrete member.
    b. Slump shall be obtained by use of mid-range or high-range water reducer conforming to ASTM C494.
3. All other members:
    a. Concrete using a water reducer per ASTM C494: 8 IN maximum, 4 IN minimum measured at the point of discharge into the concrete member.
    b. Concrete without a water reducer per ASTM C494: 5 IN maximum, 1 IN minimum measured at point of discharge into the concrete member.
4. Concrete of lower than minimum slump may be used provided it can be properly placed and consolidated.
5. Provide additional water or water reducing admixture at ready mix plant for concrete that is to be pumped to allow for slump loss due to pumping.
    a. Provide only enough additional water so that slump of concrete at discharge end of pump hose does not exceed maximum slump specified and the maximum specified water-cement ration is not exceeded.
6. Slump may be adjusted in the field through the use of water reducers.
    a. Coordinate dosage and mixing requirements with concrete supplier.
7. Slump tolerances shall comply with the requirements of ACI 117.

E. Proportioning:
1. General:
    a. Proportion ingredients to produce a mixture which will work readily into corners and angles of forms and around reinforcement by methods of placement and consolidation employed without permitting materials to segregate or excessive free water to collect on surface.
    b. Proportion ingredients to produce proper placability, durability, strength and other required properties.
2. Normal weight concrete target cementitious materials contents and maximum water cementitious ratios per Table 1 below.
    a. Target cementitious materials contents are intended to provide a crack free, durable finished product, not one with excessive strength
3. Water reducing, retarding, and accelerating admixtures:
    a. Use in accordance with manufacturer's instructions.
    b. Add to mix at batching plant.
    c. Use water-reducing or high-range water reducing admixture in concrete, as required, for placement and workability.
        1) Water reducers are required to maintain specified maximum water to cement ratios.
4. High range water reducers (superplasticizers):
    a. Use required for:
        1) All concrete to be pumped except slabs on grade.
        2) Other concrete members at Contractor’s option.
    b. Maximum concrete slump before addition of admixture to be 3 IN maximum slump after addition to be 8 IN.
    c. Reference Specification Section 03 31 31 for additional requirements.
5. Concrete mix proportioning methods for normal weight concrete:
    a. Method 1:
        1) Used when combination of materials proposed is to be evaluated and proportions selected to be on a basis of trial mixes.
        2) Produce mixes having suitable proportions and consistencies based on ACI 211.1, using at least three different water cement ratios or cement contents which will produce a range of compressive strengths encompassing the required average strength.

3) Design trial mixes to produce a slump within 0.75 IN of maximum specified, and for air entrained concrete, air content within 0.5 PCT specified.
4) For each water cement ratio or cement content, make at least three trial strength tests for specified test age, and cure in accordance with ASTM C192.
   a) Cylinder size: Per ASTM C31.
   b) Test for strength at 28 days in accordance with ASTM C39.
      (1) Quantity of cylinders per trial strength test:
         (a) 6 IN DIA cylinders: Two.
         (b) 4 IN DIA cylinders: Three.
5) From results of these tests, plot a curve showing relationship between water cement ratio or cement content and compressive strength.
6) From this curve select water cement ratio or cement content to be used to produce required average strength.
7) Use cement content and mixture proportions such that maximum water cement ratio is not exceeded when slump is maximum specified.
8) Base field control on maintenance of proper cement content, slump, air content and water cement ratio.
9) See paragraph hereafter for definition of required average strength.

b. Method 2:
1) In lieu of trial mixes, field test records for concrete made with similar ingredients may be used.
2) Use of proposed concrete mix proportions based on field test records subject to approval by Engineer based on information contained in field test records and demonstrated ability to provide the required average strength.
3) Field test records to represent materials, proportions and conditions similar to those specified.
   a) Changes in the materials, proportions and conditions within the test records shall have not been more restricted than those for the proposed concrete mix.
4) Required concrete proportions may be established by interpolation between the strengths and proportions of two or more test records each of which meets the requirements of this Specification Section.

6. Required average strength to exceed the specified 28 day compressive strength by the amount determined.

F. Flowable Fill:
1. A mixture of cement, fly ash, fine sand, water and air having a consistency which will flow under a very low head.
2. Approximate quantities of each component per cubic yard of mixed material:
   a. Cement (Type I or II): 50 LBS.
   b. Fly ash: 200 LBS.
   c. Fine sand: 2,700 LBS.
   d. Water (approximate): 420 LBS.
   e. Air content (approximate): 10 PCT.
3. Actual quantities shall be adjusted to provide a yield of 1 CUYD with the materials used.
4. Approximate compressive strength should be 85 to 175 PSI.
5. Fine sand shall be an evenly graded material having not less than 95 PCT passing the No. 4 sieve and not more than 5 PCT passing the No. 200 sieve.

G. Allowable Shrinkage:
1. Per Table 1 when tested in accordance with ASTM C157 at 28 Days.
2. Continue testing to 64 weeks for informational purposes.

TABLE 1

TYPE OF CONCRETE	28 DAY COMPRESSIVE STRENGTH	W/C RATIO	TARGET TOTAL CEMENT	SCM	ASTM C33 Size No.	AIR CONTENT	ALLOWABLE SHRINKAGE LIMIT
Normal weight lean concrete	3000 PSI	0.45	517	Note 1	7	5-1/2 to 8	None
Normal weight concrete fill utility encasement concrete	3000 PSI	0.45	517	Note 1	57	4-1/2 to 7-1/2	None
Normal weight concrete topping	4000 PSI	0.45	564	Note 1	7	5-1/2 to 8	None
Normal weight precast concrete	5000 PSI	0.42	611		57	4-1/2 to 7-1/2	None
Normal weight concrete w/ power trowel finish	4000 PSI	0.45	564	Note 1	57	0 to 2	0.048 PCT
Normal weight water-bearing concrete	4500 PSI	0.42	564	Note 1	57	4-1/2 to 7-1/2	0.032 PCT
Normal weight all other concrete	4000 PSI	0.45	564	Note 1	57	4-1/2 to 7-1/2	0.048 PCT

Table 1 Notes:

1. If fly ash is proposed for use, the weight of fly ash plus weight of Portland cement shall be used to meet total target cement requirement.

2.4 SOURCE QUALITY CONTROL

A. To assure stockpiles are not contaminated or materials are segregated, perform any test for determining conformance to requirements for cleanness and grading on samples secured from aggregates at point of batching.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Special Inspection:
   1. See Specification Section 03 00 05.

B. Perform concrete tests per Specification Section 03 00 05.
   1. Perform a strength test on all concrete to which water or superplasticizer, above the amount stated in the approved concrete mix design, has been added.
      a. Perform sampling after water or superplasticizer has been added and additional mixing has been performed.

END OF SECTION

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SECTION 03 31 31

CONCRETE MIXING, PLACING, JOINTING, AND CURING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Mixing, placing, jointing, and curing of concrete construction.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Section 03 31 30 - Concrete, Materials and Proportioning.
   4. Section 03 35 00 - Concrete Finishing and Repair of Surface Defects.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Concrete Institute (ACI):
      a. CT-13, Concrete Terminology.
      b. 117, Specification for Tolerances for Concrete Construction and Materials.
      c. 304R, Guide for Measuring, Mixing, Transporting and Placing Concrete.
      d. 304.2R, Placing Concrete by Pumping Methods.
      e. 305R, Guide to Hot Weather Concreting.
      f. 305.1, Specification for Hot Weather Concreting.
      g. 306R, Guide to Cold Weather Concreting.
      h. 306.1, Standard Specification for Cold Weather Concreting.
      i. 308.1, Specification for Curing Concrete.
      j. 309R, Guide for Consolidation of Concrete.
      k. 318, Building Code Requirements for Structural Concrete and Commentary.
      l. 360R, Guide to Design of Slabs-on-Ground.
   2. ASTM International (ASTM):
      a. C94/C94M, Standard Specification for Ready-Mixed Concrete.
      b. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
      c. C1315, Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete.
      d. D994, Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
      e. D1056, Standard Specification for Flexible Cellular Materials-Sponge or Expanded Rubber.
      f. D1751, Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
   3. Corps of Engineers (COE):
      a. CRD-C572, Specifications for Polyvinylchloride Waterstop.
   4. National Ready Mixed Concrete Association (NRMCA):
      a. Checklist for Certification of Ready Mixed Concrete Production Facilities.

B. Qualifications:
   1. Ready Mixed Concrete Batch Plant: Certified by NRMCA.

1.3 DEFINITIONS

A. Words and terms used in this Specification Section are defined in ACI CT-13.

1.4 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data including:
      a. Acknowledgement that products submitted meet requirements of standards referenced.
      b. Manufacturer's installation instructions.
         1) Procedure for adding high-range water reducer at the jobsite.
      c. Scaled (minimum 1/8 IN per foot) drawings showing proposed locations of construction joints, control joints, expansion joints (as applicable) and joint profile dimensions for each joint type.
      d. Manufacturers and types:
         1) Joint fillers.
         2) Curing agents.
         3) Construction joint bonding adhesive.
         4) Waterstops.
   3. Certifications:
      a. Ready mix concrete plant certification.

B. Informational Submittals:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Copies of concrete delivery tickets.
   3. Description of proposed curing methods.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Concrete Delivery:
   1. Prepare a delivery ticket for each load of ready mixed concrete.
   2. Truck operator shall hand ticket to Contractor at the time of delivery.
   3. Ticket to show:
      a. Mix identification.
      b. Quantity delivered.
      c. Amount of material in each batch.
      d. Outdoor temperature in the shade.
      e. Time at which cement was added.
      f. Time of delivery.
      g. Time of discharge.
      h. Amount of water that may be added at the site without exceeding the specified water-cement ratio.
      i. Amount of any approved water added at the site.

1.6 PROJECT CONDITIONS

A. Adjust concrete mix design when material characteristics, job conditions, weather, strength test results or other circumstances warrant.
   1. Do not use revised concrete mixes until submitted to and approved by Engineer.

PART 2 - PRODUCTS

2.1 PRODUCTS

A. Subject to compliance with the Contract Documents, the manufacturers listed in this article are acceptable.

B. Curing Products to conform to one or more of the following:
   1. Absorbent Covers.

a. AASHTO M182, Class 2, burlap cloth made from jute or kenaf, weighting approximately 9 OZ/SQYD (305 G/SQM) when dry.
    1) These materials must be free of harmful substances, such as sugar or fertilizer, or substances that may discolor the concrete.
    2) To remove soluble substances, burlap should be thoroughly rinsed in water before placing it on the concrete.

2. Dissipating curing compound:
    a. Fugitive dye, waterborne, membrane-forming.
    b. ASTM C309, Type 1D, Class A or B, shall be composed of hydrocarbon resins, and dissipating agents that begin to break down upon exposure to UV light, and traffic, approximately four to six weeks after applications, providing a film that is removable with standard degreasing agents, and mechanized scrubbing actions so as to not impair the later addition and performance of applied finishes.
    c. Acceptable Products:
        1) Dayton Superior Corporation; Day Chem Rez Cure (J-11-WD).
        2) Euclid Chemical Company (The); Kurez DR VOX.
        3) L&M Construction Chemicals, Inc.; L&M Cure R.

3. Clear, -borne, membrane-forming curing and sealing compound:
    a. ASTM C1315, Type 1, Class A.
    b. Moisture loss shall be not more than 0.40 KG/M^2 when applied at 300 SQFT/GAL.
    c. Manufacturer's certification is required.
    d. Subject to project requirements, provide one of the following products:
    e. Products:
        1) Euclid Chemical Company; Super Diamond Clear, Luster Seal 300 (exterior), Super Rez-Seal (interior).
        2) L&M Construction Chemicals, Inc.; Lumiseal Plus.
        3) Meadows, W.R., Inc.; CS-309/30.
        4) Euclid Chemical Company; Super Diamond Clear VOX.
        5) L&M Construction Chemicals, Inc.; Lumiseal WB Plus.
        6) Meadows, W.R., Inc.; Vocomp-30.

C. Sand cement grout, non-shrink grout and epoxy grout: See Specification Section 03 31 30 for this non-structural material and use.

2.2 SOURCE QUALITY CONTROL

A. The concrete plant shall conform to the Checklist for Certification of Ready Mixed Concrete Production Facilities of the NRMCA.

PART 3 - EXECUTION

3.1 PREPARATION

A. General:
1. All materials and construction shall conform to the tolerances as specified in ACI 117.
2. Remove earth, snow, ice, water, and other extraneous/foreign materials from areas that will receive concrete.
3. Secure reinforcement in place.
4. Obtain approval of formwork, reinforcement installation and placement prior to placing concrete.
5. Do not place concrete during rain, sleet, or snow, unless adequate protection is provided and prior Engineer approval is obtained.
    a. Plan size of crews with due regard for effects of concrete temperature and atmospheric conditions on rate of hardening of concrete as required to obtain good surfaces and avoid unplanned cold joints.
    b. Do not allow rainwater to increase mixing water nor to damage surface finish.

6. Remove hardened concrete and foreign materials from inner surfaces of conveying equipment and formwork.

B. Preparation of Subgrade for Slabs On Ground:
   1. Granular subgrade to be wetted without standing water immediately prior to placing concrete.
   2. Obtain approval of granular subgrade compaction density prior to placing slabs on ground.

C. Edge Forms and Screeds:
   1. Set accurately to produce designated elevations and contours of finished surface.
   2. Sufficiently strong to support vibrating screeds or roller pipe screeds, if required.
   3. Use strike off templates, or approved vibrating type screeds, to align concrete surfaces to contours of screed strips.

3.2 CONCRETE MIXING

A. General:
   1. Provide all concrete from a central plant conforming to Checklist for Certification of Ready Mixed Concrete Production Facilities of the NRMCA.
   2. Batch, mix, and transport in accordance with ASTM C94/C94M.

B. Control of Admixtures:
   1. Control at the batch plant:
      a. All admixtures to be introduced at the batch plant in accordance with manufacturer's recommendations.
      b. Charge admixtures into mixer as solutions.
         1) Measure by means of an approved mechanical dispensing device.
         2) Liquid considered a part of mixing water.
         3) Admixtures that cannot be added in solution may be weighed or measured by volume if so recommended by manufacturer.
      c. Add separately, when two or more admixtures are used in concrete, to avoid possible interaction that might interfere with efficiency of either admixture, or adversely affect concrete.
      d. Complete addition of retarding admixtures within one minute after addition of water to cement has been completed, or prior to beginning of last three quarters of required mixing, whichever occurs first.
   2. Control of Admixtures in the field:
      a. Additional quantities of admixtures (with the exception of retarders) may be added in the field provided:
         1) Addition of admixtures shall be under the supervision of the ready mix quality control representative.
         2) Addition of each admixture to be documented on the delivery ticket.
         3) Provide additional mixing per ASTM C94.

C. Tempering and Control of Mixing Water:
   1. Mix concrete only in quantities for immediate use.
   2. Discard concrete which has set.
   3. Discharge concrete from ready mix trucks within time limit stated in ASTM C94.
   4. Addition of water at the jobsite:
      a. See Specification Section 03 31 30 for specified water cement ratio and slump.
      b. Do not exceed maximum specified water cement ratio or slump.
      c. Incorporate water by additional mixing equal to at least half of total mixing required.

3.3 PLACING OF CONCRETE

A. General:
   1. Place concrete as such a rate that concrete, which is being integrated with fresh concrete, is still workable.

a. Select placement equipment and manpower in order to assure timely delivery of concrete into forms to avoid unintended cold joints and placement consolidation issues.

2. Comply with ACI 304R and ACI 304.2R.
3. Do not begin placing concrete during rain, sleet, or snow.
   a. Protect fresh concrete from ensuing inclement weather.
4. Do not deposit concrete which has partially hardened or has been contaminated by foreign materials.
5. Begin work only when work of other trades affecting concrete is complete.
6. Do not use excess grout or mortar to lubricate lines when pumping concrete.
7. Do not use excess water for workability or any reason when placing concrete by freefall.
8. Deposit concrete continuously to avoid cold joints.
9. Locate construction joints at locations specified or approved by Engineer.
   a. Plan size of crews with due regard for effects of concrete temperature and atmosphere conditions to avoid unplanned cold joints.
10. Spreaders:
    a. Temporary: Remove as soon as concrete placing renders their function unnecessary.
    b. Embedded:
       1) Obtain approval of Engineer for their use.
       2) Materials: Concrete or metal.
       3) Ends of metal spreaders coated with plastic coating 2 IN from each end.
11. Deposit concrete as nearly as practicable in its final position to avoid segregation.
    a. Maximum free fall: 4 FT.
    b. Place concrete by means of hopper, elephant trunk or tremie pipe extending down to within 4 FT of surface.
12. Perform the following operations before bleeding water has an opportunity to collect on surface:
    a. Spread.
    b. Consolidate.
    c. Straightedge.
    d. Darby or bull float.
13. No water shall be added to the concrete surface to ease finishing operation.
14. Do not discharge water into forms.
15. Consider use of form vibrators for certain placement situations.
16. When replacing existing concrete, install rebar embedded into existing concrete to match size and placement of rebar removed.

B. Cold Weather Concrete Placement:
   1. Comply with ACI 306.1.
   2. Do not place concrete on forms or subgrades that are below 32 DEGF or contain frozen material.
   3. Maintain all materials, forms, reinforcement, subgrade and any other items which concrete will come in contact with free of frost, ice or snow at time of concrete placement.
   4. Temperature of concrete when discharged at site: Per ACI 306.1.
   5. Heat subgrade forms, embedments and reinforcement to between 45 and 70 DEGF, when temperature of surrounding air is 40 DEGF or below at time concrete is placed.
      a. Remove all frost from subgrade, forms and reinforcement before concrete is placed.
   6. Combine water with aggregate in mixer before cement is added, if water or aggregate is heated above 90 DEGF.
   7. Do not mix cement with water or with mixtures of water and aggregate having a temperature greater than 90 DEGF.
   8. Follow ACI 306R for specific requirements dealing with elevated steel troweled slabs that will be exposed to freeze-thaw cycles.

C. Hot Weather Concrete Placement:
   1. Comply with ACI 305.1.

2. Cool ingredients before mixing, or add flake ice or well crushed ice of a size that will melt completely during mixing for all or part of mixing water if high temperature, low slump, flash set, cold joints, or shrinkage cracks are encountered.
3. Temperature of concrete at point of delivery (i.e. truck discharge) when placed:
    a. Not to exceed 90 DEGF.
    b. Not so high as to cause:
        1) Shrinkage cracks.
        2) Difficulty in placement due to loss of slump.
        3) Flash set.
4. Temperature of forms and reinforcing when placing concrete:
    a. Not to exceed 90 DEGF.
    b. May be reduced by spraying with water to cool below 90 DEGF.
        1) Leave no standing water to contact concrete being placed.
5. Prevent plastic shrinkage cracking and/or slab curling due to evaporation.

D. Consolidating:
1. Consolidate in accordance with ACI 309R except as modified herein.
2. Consolidate by vibration so that concrete is thoroughly worked around reinforcement, embedded items and into corners of forms.
    a. Ensure no displacement of reinforcing or other embeds from final position.
    b. Eliminate:
        1) Air or stone pockets.
        2) Honeycombing or pitting.
        3) Planes of weakness.
3. Use suitable form vibrators located just below top surface of concrete, where internal vibrators cannot be used in areas of congested reinforcing.
    a. Size and coordinate external vibrators to specifically match forming system used.
4. Internal vibrators:
    a. Minimum frequency of 8000 vibrations per minute.
    b. Insert and withdraw at points approximately 18 IN apart.
        1) Allow sufficient duration at each insertion to consolidate concrete but not sufficient to cause segregation.
    c. Use in:
        1) Beams and girders of framed slabs.
        2) Columns and walls.
        3) Vibrating concrete around all waterstops.
    d. Size of vibrators shall be in accordance with ACI 309R, Table 5.1.5.
5. Obtain consolidation of slabs with internal vibrators, vibrating screeds, roller pipe screeds, or other approved means.
6. Do not use vibrators to transport concrete within forms.
7. When placing self-consolidating concrete, the use of form or pencil vibrators is acceptable, provided such methods do not cause aggregate segregation, or otherwise adversely affect the quality of the work.
8. Provide sufficient spare vibrators on jobsite during all concrete placing operations to assure continuous vibration.
9. Bring a full surface of mortar against form by vibration supplemented if necessary by spading to work coarse aggregate back from formed surface, where concrete is to have an as-cast finish.
10. Prevent construction equipment, construction operations, and personnel from introducing vibrations into freshly placed concrete after the concrete has been placed and consolidated.

E. Handle concrete from mixer to place of final deposit by methods which will prevent segregation or loss of ingredients and in a manner which will assure that required quality of concrete is maintained.
1. Use truck mixers, agitators, and non-agitating units in accordance with ASTM C94.
2. Horizontal belt conveyors:

a. Mount at a slope which will not cause segregation or loss of ingredients.
b. Protect concrete against undue drying or rise in temperature.
c. Use an arrangement at discharge end to prevent segregation.
d. Do not allow mortar to adhere to return length of belt.
e. Discharge conveyor runs into equipment specially designed for spreading concrete.

3. Metal or metal lined chutes:
   a. Slope not exceeding 1 vertical to 2 horizontal and not less than 1 vertical to 3 horizontal.
   b. Chutes more than 20 FT long and chutes not meeting slope requirements may be used provided they discharge into a hopper before distribution.
   c. Provide end of each chute with a device to prevent segregation.
4. Pumping or pneumatic conveying equipment:
   a. Designed for concrete application and having adequate pumping capacity.
   b. Control pneumatic placement so segregation is avoided in discharged concrete.
   c. Loss of slump in pumping or pneumatic conveying equipment shall not exceed 1-1/2 IN.
   d. Do not convey concrete through pipe made of aluminum or aluminum alloy.
   e. Provide pumping equipment without Y sections.

3.4 JOINTS AND EMBEDDED ITEMS

A. Other Embedded Items:
1. Place sleeves, inserts, anchors, and embedded items required for adjoining work or for its support, prior to initiating concreting.
   a. Give Contractor whose work is related or integral to concrete, or supported by it, ample notice and opportunity to furnish and install items before placing concrete.
2. Do not route electrical conduit, drains, or pipes in concrete slabs, walls, columns, foundations, beams or other structural members unless approved by Engineer.

B. Placing Embedded Items:
1. Support against displacement.
2. Fill voids in sleeves, inserts and anchor slots temporarily with readily removable material to prevent entry of concrete into voids.
3. Provide adequate means for anchoring waterstop in concrete.
   a. Provide means to prevent waterstops in the forms from being folded over by the concrete as it is placed.
4. Embed reinforcing into hardened concrete utilizing adhesive anchor system specifically manufactured for such installation:
   a. Drill hole in concrete with diameter and depth as required to develop 125 PCT of the yield strength of the bar according to manufacturer's requirements.
   b. Clean holes per manufacturer's recommendations.
   c. Place adhesive in drilled hole.
   d. Insert reinforcing into hole and adhesive in accordance with manufacturer's recommendations.

3.5 FINISHING

A. See Specification Section 03 35 00.

B. Coordinate mixing and placing with finishing.

3.6 CURING AND PROTECTION

A. Protect concrete from premature drying, excessively hot or cold temperatures, and mechanical injury immediately after placement, and maintain with minimal moisture loss at relatively constant temperature for period necessary for hydration of cement, hardening, and compressive strength gain.
1. Follow recommendations of ACI 308.1 except as modified herein.

2. Do not impose loads by foot traffic, wheeled traffic, and other loads until concrete has sufficiently cured to carry imposed loads without adversely affecting the concrete. In no event shall concrete be subject to loading or traffic during initial 48 HRS of curing, unless otherwise approved by Engineer.

B. For surfaces of non-water bearing structures, apply one of the following curing procedures immediately after completion of placement and finishing (surfaces not in contact with forms).
   1. Ponding or continuous sprinkling. Take care to avoid eroding the surface of freshly placed concrete.
   2. Application of wet Absorbent Covers:
      a. Minimum lap: 12 IN.
      b. Provide continuous uniform supply of moisture, such as sprinklers or soaker hoses as required to keep concrete surface continuously wet.
      c. Monitor Absorbent Covers as required to prevent cover materials or concrete surface from drying out.
   3. Continuous application of steam (not exceeding 150 DEGF) or mist spray.
   4. Application of Moisture Retaining Cover sheet materials.
      a. Place as soon as possible after final finishing and without marring the surface.
      b. Minimum lap: 12 IN.
      c. Seal all edges to make water-tight.
      d. Place Moisture Retaining Cover in intimate contact with the concrete surface, without wrinkles and weighted to hold in place.
      e. Hold cover and edges in place as required to prevent wind from displacing the cover.
      f. Moisture Retaining Fabric:
         1) Install in accordance with manufacturer's written recommendations.
         2) Saturate concrete surface and fabric side of cover immediately prior to placing.
      g. Monitor continuously during the curing period:
         1) Repair any holes, tears or displaced cover.
         2) Rewet as required to keep concrete moist under cover.
   5. Application of other moisture retaining covering as approved by Engineer.
   6. Water used for curing shall be within 20 DEGF of the concrete temperature.
   7. Application of a curing compound.
      a. Apply curing compound in accordance with manufacturer's recommendations immediately after any water sheen, which may develop after finishing, has disappeared from concrete surface.
      b. Do not use on any surface against which additional concrete or other material is to be bonded unless it is proven that curing compound will not prevent bond.
      c. Where a vertical surface is cured with a curing compound, the vertical surface shall be covered with a minimum of two coats of the curing compound.
         1) Apply the first coat of curing compound to a vertical surface immediately after form removal.
         2) The vertical concrete surface at the time of receiving the first coat shall be damp with no free water on the surface.
         3) Allow the preceding coat to completely dry prior to applying the next coat.
         4) A vertical surface: Any surface steeper than 1 vertical to 4 horizontal.
   8. Surfaces In Contact with Forms:
      a. Formed surfaces: Cure formed concrete surfaces utilizing final curing methods per ACI 308.1, including underside of beams, supported slabs, and other similar surfaces,
      b. Minimize moisture loss from and temperature gain of concrete placed in forms exposed to heating by sun by keeping forms wet and cool until they can be safely removed.
      c. Make provisions to keep concrete wall moist while stripping forms and until curing measures are in place.
      d. After form removal, cure concrete until end of time prescribed.
      e. Use one of the methods listed above.
      f. Forms left in place shall not be used as a method of curing in hot weather.
      g. The term "hot weather", where used in these specifications, is defined in ACI 305.1.

h. In hot weather, remove forms from vertical surfaces as soon as concrete has gained sufficient strength so that the formwork is no longer required to support the concrete.

C. Curing Period:
1. Continue curing for at least seven days for all concrete except Type III, high early strength concrete for which period shall be at least three days.
a. If one of curing procedures indicated above is used initially, it may be replaced by one of other procedures indicated any time after concrete is two days old, provided concrete is not permitted to become surface dry during transition.

D. Cold Weather:
1. Follow recommendations of ACI 306.1.
2. Maintain temperature of concrete per ACI 306.1 for a minimum of 72 HRs after concrete is placed, when outdoor temperature is 40 DEGF, or less.
a. Maximum temperature rate of decrease: Per ACI 306.1.
3. Use heating, covering, insulating, or housing of the concrete work to maintain required temperature without injury due to concentration of heat.
4. Do not use combustion heaters unless precautions are taken to prevent exposure of concrete to exhaust gases which contain carbon dioxide.
5. Interior slabs in areas intended to be heated shall be adequately protected so that frost does not develop in the supporting subgrade.

E. Hot Weather:
1. Follow recommendations of ACI 305.1 and ACI 308.1.
2. Make provision for cooling forms, reinforcement and concrete, windbreaks, shading, fog spraying, sprinkling, ponding, or wet covering with a light colored material.
3. Provide protective measures as quickly as concrete hardening and finishing operations will allow.
4. Maximum temperature rate of decrease: Per ACI 305.1.

F. Rate of Temperature Change:
1. Keep changes in temperature of air immediately adjacent to concrete as uniform as possible, during and immediately following curing period.

G. Protection from Mechanical Injury:
1. Protect concrete from damaging mechanical disturbances, such as load stresses, heavy shock, and excessive vibration.
2. Protect finished concrete surfaces from damage by construction equipment, materials, or methods, and by rain or running water.
3. Do not load self-supporting structures in such a way as to overstress concrete.

END OF SECTION

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SECTION 03 35 00

CONCRETE FINISHING AND REPAIR OF SURFACE DEFECTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Concrete finishing and repair of surface defects.
   2. Chemical Sealers.
   3. Polymer Modified Cementitious Coating.
   4. Resurfacing Mortar.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Section 03 31 30 - Concrete, Materials and Proportioning.
   4. Section 03 31 31 - Concrete Mixing, Placing, Jointing and Curing.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Concrete Institute (ACI):
      a. CT-13, Concrete Terminology.
      b. 117, Specification for Tolerances for Concrete Construction and Materials.
      c. 303R, Guide to Cast-in-Place Architectural Concrete Practice.
      d. 308, Standard Practice for Curing Concrete.
   2. ASTM International (ASTM):
      a. C109, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens).
      b. C150, Standard Specification for Portland Cement.
      c. C157, Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
      d. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
      e. C666, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.
      f. C779, Standard Test Method for Abrasion Resistance of Horizontal Concrete Surfaces.
      g. C1315, Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete.
      h. D4258, Standard Practice for Surface Cleaning Concrete for Coating.
      i. D4259, Standard Practice for Abrading Concrete.
      j. E1155, Standard Test Method for Determining F(F) Floor Flatness and F(L) Floor Levelness Numbers.
      k. E1486, Standard Test Method for Determining Floor Tolerances Using Waviness, Wheel Path and Levelness Criteria.
   3. International Concrete Repair Institute (ICRI):
      a. 310.2R, Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays.
   4. National Council Highway Research Program (NCHRP):
      a. 244, Concrete Sealers for the Protection of Bridge Structures.
   5. The Society for Protective Coatings/NACE International (SSPC/NACE):
      a. SP 13/NACE No. 6, Surface Preparation of Concrete.

1.3 DEFINITIONS

A. Installer or Applicator:

1. Installer or applicator is the person actually installing or applying the product in the field at the Project site.
2. Installer and applicator are synonymous.

B. Other words and terms used in this Specification Section are defined in ACI CT-13.

1.4 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data including:
      a. Acknowledgement that products submitted meet requirements of standards referenced.
      b. Manufacturer's installation instructions.
   3. Certifications:
      a. Certification of aggregate gradation.
      b. Certification of manufacturer experience qualifications and performance history.
      c. Certification of applicator's qualifications.
         1) Refer to Qualifications paragraph.
         2) Provide manufacturer's written approval of applicators.
         3) Provide references substantiating specialty experience.

B. Informational Submittals:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Comply with manufacturer's recommendations and requirements for materials used.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Bonding Agents:
      a. BASF Master Builders Solutions.
      b. Euclid Chemical Co.
      c. Laticrete - L&M Construction Chemicals.
   2. Chemical Sealers:
      a. BASF Master Builders Solutions.
      b. Euclid Chemical Co.
      c. Laticrete - L&M Construction Chemicals.
      d. Tnemec Chemprobe.
   3. Polymer Modified Cementitious Coating:
      a. Aquafin International.
      b. BASF Master Builders Solutions.
      c. Euclid Chemical Co.
   4. Patching Mortar:
      a. BASF Master Builders Solutions.
      b. Euclid Chemical Co.
      c. Laticrete - L&M Construction Chemicals.
      d. Sika Corporation.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 MATERIALS

A. Chemical Sealer CS-3:

1. Clear, penetrating, breathable, waterborne silane-siloxane solution.
2. VOC content: ≤50 G/L.
3. Odorless.
4. Flash point: >200 DEGF.
5. Water absorption: 85 PCT reduction per NCHRP 244.
6. Chloride penetration: 82 PCT reduction per NCHRP 244.
7. Euclid Chemical Baracade WB 244.

B. Patching Mortar: Trowelable cementitious repair mortar for vertical, overhead, and horizontal repairs.
   1. Portland cement-based, rapid set repair mortar for interior or exterior use.
   2. Compressive Strength, ASTM C109:
      a. Minimum 3000 PSI at 7 days.
      b. Minimum 5000 PSI at 28 days.
   3. Freeze Thaw Durability, ASTM C666: 96.75 PCT at 300 Cycles.
   4. Shrinkage, ASTM C157: 0.069 PCT.
   5. Euclid Chemical Speed Crete Red Line.

C. Bonding Agents:
   1. For use only on concrete surfaces not receiving liquid water repellent coating:
      a. High solids acrylic latex base liquid for interior or exterior application as a bonding agent to improve adhesion and mechanical properties of concrete patching mortars.
         1) BASF Master Builders MasterEmaco A 660.
         2) Euclid Chemical Co. Flex-Con.
         3) Laticrete L&M Everbond.
   2. For use only on concrete surface receiving liquid water repellent:
      a. Non-acrylic base liquid for interior or exterior application as a bonding agent to improve adhesion and mechanical properties of concrete patching mortars.

D. Cement:
   1. ASTM C150, Type II Portland for areas exposed to sewage.
   2. ASTM C150, Type I III IV Portland elsewhere.

E. Aggregate:
   1. Sand: Maximum size #30 mesh sieve.
   2. For exposed aggregate finish surfaces: Same as surrounding wall.

F. Water: Potable.

G. Polymer modified cementitious coating:
   1. Polymer modified Portland cement based coating for concrete and masonry.
      a. Waterproof.
      b. Resistant to both positive and negative hydrostatic pressure.
      c. Breathable.
   2. BASF MasterSeal 581 or Euclid Chemical Tamoseal.
      a. Color:
         1) Interior surfaces: none.
         2) Exterior surfaces: Standard gray.
      b. Texture: Fine.

H. Nonshrink Grout: See Specification Section 03 31 30 and Specification Section 03 31 31.

2.3 MIXES

A. Bonding Grout: One part cement to one part aggregate.

B. Patching Mortar:
   1. One part cement to 2-1/2 parts aggregate by damp loose volume.
      a. Substitute white Portland cement for a part of gray Portland cement to produce color matching surrounding concrete.

PART 3 - EXECUTION

3.1 PREPARATION

A. For methods of curing, see Specification Section 03 31 31.

B. Surface Preparation:
   1. Clean surfaces in accordance with ASTM D4258 to remove dust, dirt, form oil, grease, or other contaminants prior to abrasive blasting, chipping, grinding or wire brushing.
   2. Prepare surfaces in accordance with ASTM D4259 and SSPC SP 13/NACE No. 6 to completely open defects down to sound concrete and remove laitance.
      a. Provide concrete surface profile (CSP) in accordance with ICRI 310.2:
         1) Areas to receive Repair Mortar:
            a) Areas larger than 1 SF or deeper than 1/4 IN Abrasive blast, scarify or needle scale to CSP No. 6-8.
      b. If additional chipping or wire brushing is necessary, make edges perpendicular to surface or slightly undercut.
      c. No featheredges will be permitted.
      d. Rinse surface with clean water to remove all dust, dirt, debris, loosened concrete, laitance, and other contaminants.

C. Preparation of Bonding Grout Mixture:
   1. Mix cement and aggregate.
   2. Mix bonding agent and water together in separate container in accordance with manufacturer's instructions.
   3. Add bonding agent/water mixture to cement/aggregate mixture.
   4. Mix to consistency of thick cream.
   5. Bonding agent itself may be used as bonding grout if approved by manufacturer and Engineer.

D. Preparation of Patching Mortar Mixture:
   1. Mix specified patching mortar per manufacturer’s published recommendations.
   2. For repairs exceeding 2 IN in depth, mix with clean, pre-dampened 3/8 IN pea gravel in accordance with the manufacturer’s recommendations.

E. Polymer modified cementitious coating:
   1. Mix in accordance with manufacturer's recommendations using bonding agent acceptable to coating manufacturer.

3.2 INSTALLATION AND APPLICATION

A. Do not repair surface defects or apply wall or floor finishes when temperature is or is expected to be below 50 DEGF.
   1. If necessary, enclose and heat area to between 50 and 70 DEGF during repair of surface defects and curing of patching material.
      a. Use only clean fuel, indirect fired heating apparatus.
      b. Exhaust combustion byproducts outside of work area.

B. Chemical Sealer Application:
   1. General:
      a. Immediately prior to Substantial Completion, thoroughly clean floor in accordance with ASTM D4258 and prepare to receive chemical sealer.
         1) Remove previously applied membrane curing compounds.
         2) Remove soil, oils, stains, discoloration, or any other imperfection having a negative impact on the appearance of the finished floor.
      b. Apply product to floor areas indicated on the Drawings.
      c. Apply in accordance with manufacturer's published installation instructions.
   2. Chemical Sealer (CS-3):
      a. Apply uniform coats at rate recommended by manufacturer.
         1) Apply with fine, uniform spray or microfiber pad.

b. Allow floor to dry completely and remove any dried residue using hot water and mild citric acid.
c. Final floor finish shall be uniform, free of residue, and shall repel water.
d. Apply additional coat(s) as necessary to achieve water repellent finish.

C. Repairing Surface Defects:
1. This method is to be used on vertical concrete surfaces as indicated in the Concrete Finishes for Vertical Wall Surfaces paragraph of this Specification Section and similar concrete surfaces not otherwise specified to receive another finish or coating.
2. Fill and repair surface defects and tie-holes using patching mortar mix specified in the MATERIALS Article in PART 2.
a. Prime exposed reinforcing steel, embeds or other steel surfaces with primer as recommended by patching mortar manufacturer.
b. Scrub bond coat:
1) Wet substrate to a saturated surface dry (SSD) condition.
2) Mix patching mortar to a scrub coat or slurry consistency per manufacturer's published recommendations and apply to entire area.
c. As an alternate to the scrub bond coat, concrete may be primed with manufacturer's recommended epoxy primer.
d. Patching Mortar Application:
1) Mix and apply Patching Mortar per manufacturer's recommendations within the open time of the product scrub coat or any bonding agents.
2) Finish to level of surrounding concrete surface utilizing techniques recommended by manufacturer.
3. Consolidate patching mortar into place and strike off so as to leave patch slightly higher than surrounding surface.
4. Leave undisturbed until mortar has stiffened before finishing level with surrounding surface.
a. Do not use steel tools in finishing a patch in a formed wall which will be exposed to view.
5. Cure patching mortar in accordance with ACI 308.

D. Related Unformed Surfaces (Except Slabs):
1. Strike smooth and level tops of walls or buttresses, horizontal offsets, and similar unformed surfaces occurring adjacent to formed surfaces after concrete is placed.
2. Float surface to a texture consistent with that of formed surfaces.
a. If more than one finish occurs immediately adjacent to unformed surface, provide surface with most stringent formed surface requirement.
3. Continue treatment uniformly across unformed surfaces.

E. Concrete Finishes for Horizontal Slab Surfaces:
1. General:
a. Tamp concrete to force coarse aggregate down from surface.
b. Screed with straightedge, eliminate high and low places, bring surface to required finish elevations; slope uniformly to drains.
c. Dusting of surface with dry cement or sand during finishing processes not permitted.
2. Unspecified slab finish:
a. When type of finish is not indicated, use following finishes as applicable:
1) Surfaces intended to receive bonded applied cementitious applications: Scratched finish.
2) Exterior slabs, sidewalks, platforms, steps and landings, and ramps, not covered by other finish materials: Broom or belt finish.
3) All slabs to receive a floated finish before final finishing.
3. Scratched slab finish: After concrete has been placed, consolidated, struck off, and leveled to a Class B tolerance, roughen surface with stiff brushes or rakes before final set.
4. Floated finish:
a. After concrete has been placed, consolidated, struck off, and leveled to a Class B tolerance, do no further work until ready for floating.

b. Begin floating when water sheen has disappeared and surface has stiffened sufficiently to permit operations.
    1) Use wood or cork float.
c. During or after first floating, check planeness of entire surface with a 10 FT straightedge applied at not less than two different angles.

5. Cut down all high spots and fill all low spots to produce a surface with Class B tolerance throughout.
    a. Refloat slab immediately to a uniform texture.
6. Troweled finish:
    a. Float finish surface to true, even plane.
    b. Power trowel, and finally hand trowel.
    c. First troweling after power troweling shall produce a smooth surface which is relatively free of defects, but which may still show some trowel marks.
    d. Perform additional trowelings by hand after surface has hardened sufficiently.
    e. Final trowel when a ringing sound is produced as trowel is moved over surface.
    f. Thoroughly consolidate surface by hand troweling.
    g. Finish in accordance with the FIELD QUALITY CONTROL Article in PART 3 of this Specification Section.
        1) Leave finished surface essentially free of trowel marks, uniform in texture and appearance.
    h. On surfaces intended to support floor coverings, remove any defects that would show through floor covering.
7. Broom or belt finish: Immediately after concrete has received a float finish as specified, give it a transverse scored texture by drawing a broom or burlap belt across surface.
8. Underside of concrete slab finish:
    a. Match finish as specified for adjacent vertical surfaces.
    b. If more than one finish occurs immediately adjacent to underside of slab surface, provide surface with most stringent formed surface requirement.

3.3 FIELD QUALITY CONTROL

A. Tolerances:

B. Unacceptable finishes shall be replaced or, if approved in writing by Engineer, may be corrected provided strength and appearance are not adversely affected.
    1. High spots to be removed by grinding and/or low spots filled with a patching compound or other remedial measures to match adjacent surfaces.

C. Provide services of manufacturer's technical representative:
    1. A certified manufacturer's representative experienced in the use of the products used shall be present on a full-time basis to observe and oversee all operations associated with the installation.
    2. Contractor, along with manufacturer, shall be fully responsible for the proper application, including all means and methods incidental thereto necessary for a sound, secure and complete installation.
    3. Manufacturer's representative shall be present for installation of:
        a. Dry-shake Hardener.
        b. Heavy-duty Metallic Aggregate Topping.

3.4 PROTECTION

A. All horizontal slab surfaces receiving chemical sealer shall be kept free of traffic and loads for minimum of 72 HRS following installation of sealer.

END OF SECTION

DIVISION 10

SPECIALTIES

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SECTION 10 14 00
IDENTIFICATION DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Tag, tape and stenciling systems for equipment, ductwork and similar items.
   2. Hazard and safety signs.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Society of Mechanical Engineers (ASME):
      a. A13.1, Scheme for the Identification of Piping Systems.
   2. The International Society of Automation (ISA).
   3. National Electrical Manufacturers Association/American National Standards Institute (NEMA/ANSI):
      a. Z535.1, Safety Color Code.
      b. Z535.2, Environmental and Facility Safety Signs.
      c. Z535.3, Criteria for Safety Symbols.
      d. Z535.4, Product Safety Signs and Labels.
   4. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
      b. 704, Standard System for the Identification of Hazards of Materials for Emergency Response.
   5. Occupational Safety and Health Administration (OSHA):
      a. 29 CFR 1910.145, Specification for Accident Prevention Signs and Tags.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data including:
      a. Catalog information for all identification systems.
      b. Acknowledgement that products submitted meet requirements of standards referenced.
   3. Identification register, listing all items in PART 3 of this Specification Section to be identified, type of identification system to be used, lettering, location and color.
   4. Schedule of Hazard and Safety Signage indicating text and graphics.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. W.H. Brady Co.
   2. Panduit.
   3. Seton.
   4. National Band and Tag Co.
   5. Carlton Industries, Inc.

B. Submit request for substitution in accordance with Specification Section 01 25 13.

2.2 MANUFACTURED UNITS

A. Type A1 - Round Metal Tags:
   1. Materials:
      a. Aluminum or stainless steel.
      b. Stainless steel shall be used in corrosive environments.
   2. Size:
      a. Diameter: 1-1/2 IN minimum.
      b. Thickness: 0.035 IN (20 GA) minimum.
   3. Fabrication:
      a. 3/16 IN minimum mounting hole.
      b. Legend: Stamped and filled with black coloring.
   4. Color: Natural.

B. Type A2 - Rectangle Metal Tags:
   1. Materials: Stainless steel.
   2. Size:
      a. 3-1/2 IN x 1-1/2 IN minimum.
      b. Thickness: 0.036 IN (20 GA) minimum.
   3. Fabrication:
      a. 3/16 IN minimum mounting hole.
      b. Legend: Stamped and filled with black coloring.
   4. Color: Natural.

C. Type A3 - Metal Tape Tags:
   1. Materials: Aluminum or stainless steel.
   2. Size:
      a. Width 1/2 IN minimum.
      b. Length as required by text.
   3. Fabrication:
      a. 3/16 IN minimum mounting hole.
      b. Legend: Embossed.
   4. Color: Natural.

D. Type B1- Square Nonmetallic Tags:
   1. Materials: Fiberglass reinforced plastic.
   2. Size:
      a. Surface: 2 x 2 IN minimum.
      b. Thickness: 100 MILS.
   3. Fabrication:
      a. 3/16 IN mounting hole with metal eyelet.
      b. Legend: Preprinted and permanently embedded and fade resistant.
   4. Color:
      a. Background: Manufacturer standard or as specified.
      b. Lettering: Black.

E. Type B2 - Nonmetallic Signs:
   1. Materials: Fiberglass reinforced or durable plastic.
   2. Size:
      a. Surface: As required by text.
      b. Thickness: 60 MILS minimum.
   3. Fabrication:
      a. Rounded corners.
      b. Drilled holes in corners with grommets.
      c. Legend: Preprinted, permanently embedded and fade resistant for a 10 year minimum outdoor durability.

4. Color:
    a. Background: Manufacturer standard or as specified.
    b. Lettering: Black.
5. Standards for OSHA signs: NEMA/ANSI Z535.1, NEMA/ANSI Z535.2, NEMA/ANSI Z535.3, NEMA/ANSI Z535.4, OSHA 29 CFR 1910.145.

F. Type C - Laminated Name Plates:
1. Materials: Phenolic or DR (high impact) acrylic.
2. Size:
    a. Surface: As required by text.
    b. Thickness: 1/16 IN.
3. Fabrication:
    a. Outdoor rated and UV resistant when installed outdoors.
    b. Two layers laminated.
    c. Legend: Engraved through top lamination into bottom lamination.
    d. Two drilled side holes, for screw mounting.
4. Color: Black top surface, white core, unless otherwise indicated.

G. Type D - Self-Adhesive Tape Tags and Signs:
1. Materials: Vinyl tape or vinyl cloth.
2. Size:
    a. Surface: As required by text.
    b. Thickness: 5 MILS minimum.
3. Fabrication:
    a. Indoor/Outdoor grade.
    b. Weather and UV resistant inks.
    c. Permanent adhesive.
    d. Legend: Preprinted.
    e. Wire markers to be self-laminating.
4. Color: White with black lettering or as specified.
5. Standards for OSHA signs: NEMA/ANSI Z535.1, NEMA/ANSI Z535.2, NEMA/ANSI Z535.3, NEMA/ANSI Z535.4, OSHA 29 CFR 1910.145.

H. Type E - Heat Shrinkable Tape Tags:
1. Materials: Polyolefin.
2. Size: As required by text.
3. Fabrication:
    a. Legend: Preprinted.
4. Color: White background, black printing.

I. Type F - Underground Warning Tape:
1. Materials: Polyethylene.
2. Size:
    a. 6 IN wide (minimum).
    b. Thickness: 3.5 MILS.
3. Fabrication:
    a. Legend: Preprinted and permanently imbedded.
    b. Message continuous printed.
    c. Tensile strength: 1750 PSI.
4. Color: As specified.

J. Type G - Stenciling System:
1. Materials:
    a. Exterior type stenciling enamel.
    b. Either brushing grade or pressurized spray can form and grade.
2. Size: As required.
3. Fabrication:
    a. Legend: As required.

4. Color: Black or white for best contrast.

K. Underground Tracer Wire:
   1. Materials:
      a. Wire:
         1) 12 GA AWG.
         2) Solid.
      b. Wire nuts: Waterproof type.
      c. Split bolts: Brass.

2.3 ACCESSORIES

A. Fasteners:
   1. Bead chain: #6 brass, aluminum or stainless steel.
   2. Plastic strap: Nylon, urethane or polypropylene.
   3. Screws: Self-tapping, stainless steel.
   4. Adhesive, solvent activated.

2.4 MAINTENANCE MATERIALS

A. Where stenciled markers are provided, clean and retain stencils after completion and include in extra stock, along with required stock of paints and applicators.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. Install identification devices at specified locations.

B. All identification devices to be printed by mechanical process, hand printing is not acceptable.

C. Attach tags to equipment with sufficient surface or body area with solvent activated adhesive applied to back of each tag.

D. Attach tags with 1/8 IN round or flat head screws to equipment without sufficient surface or body area, or porous surfaces.
   1. Where attachment with screws should not or cannot penetrate substrate, attach with plastic strap.

E. Single items of equipment enclosed in a housing or compartment to be tagged on outside of housing.
   1. Several items of equipment mounted in housing to be individually tagged inside the compartment.

F. Tracer Wire:
   1. Attach to pipe at a maximum of 10 FT intervals with tape or tie-wraps.
   2. Continuous pass from each valve box and above grade at each structure.
   3. Coil enough wire at each valve box to extend wire a foot above the ground surface.
   4. 1,000 FT maximum spacing between valve boxes.
   5. If split bolts are used for splicing, wrap with electrical tape.
   6. If wire nuts are used for splicing, knot wire at each splice point leaving 6 IN of wire for splicing.
   7. Use continuous strand of wire between valve box where possible.
      a. Continuous length shall be no shorter than 100 FT.

3.2 SCHEDULES

A. Hazard and Safety Signage:
   1. Miscellaneous OSHA hazard signage:
      a. Tag Type: Type B2 - Nonmetallic Signs.
      b. Fastener: Screw or adhesive.

c. Size: 10 IN x 14 IN.
d. Location: As indicated on Drawings.
e. Location: Field located as directed by Engineer.
    1) Allowance: Provide 10 OSHA Danger, Caution, Safety Instruction or Biohazard signs as directed by Engineer.
f. Legend:
    1) Description of hazard shall be determined by Engineer.
    2) Provide international graphic symbology where indicated.

B. Electrical Systems:
1. Trenches with ductbanks, direct-buried conduit, or direct-buried wire and cable.
    a. Tag type: Type F - Underground Warning Tape.
    b. Letter height: 1-1/4 IN minimum.
    c. Location:
        1) Where trench is 12 IN or more below finished grade: In trench 6 IN below finished grade.
        2) Where trench is less than 12 IN below finished grade: In trench 3 IN below finished grade.
    d. Electrical power (e.g., low and medium voltage):
        1) Color: Red with black letters.
        2) Legend:
            a) First line: “CAUTION CAUTION CAUTION”.
            b) Second line: “BURIED ELECTRIC LINE BELOW”.
    e. Communications (e.g., telephone, instrumentation, LAN, SCADA):
        1) Color: Orange with black letters.
        2) Legend:
            a) First line: “CAUTION CAUTION CAUTION”.
            b) Second line: “BURIED COMMUNICATION LINE BELOW”.
2. Switchgear, switchboards and motor control centers:
    a. Tag type: Type C - Phenolic Name Plates.
    b. Fastener: Screws.
    c. Main equipment legend:
        1) Letter height:
            a) First line: 1 IN minimum.
            b) Subsequent lines: 3/8 IN minimum.
        2) First line: Equipment name (e.g., "MAIN SWITCHBOARD MSBxxx").
        3) Second line:
            a) Source of power (e.g., "FED FROM MCCxxx LOCATED IN ROOM xxx").
            b) Include the building name or number if the source is in another building.
        4) Third line: System voltage and phase (e.g., “480/277 V, 3PH”).
        5) Fourth line: Date installed (e.g., “INSTALLED JULY 20xx”).
    d. Main and feeder device legend:
        1) Letter height: 3/8 IN minimum.
        2) Description of load (e.g., “MAIN DISCONNECT”, "PUMP Pxxx" or "PANELBOARD HPxxx").
3. Panelboards and transformers:
    a. Tag type: Type C - Phenolic Name Plates.
    b. Fastener: Screws.
    c. Legend:
        1) Letter height:
            a) First line: 3/8 IN minimum.
            b) Subsequent lines: 3/16 IN minimum.
        2) First line: Equipment name (e.g., "PANELBOARD LPxxx" or "TRANSFORMER Txxx").
        3) Second line (panelboards only): System voltage and phase (e.g., “208/120V, 3PH”).

4) Third line:
    a) Source of power (e.g., "FED FROM MCCxxx LOCATED IN ROOM xxx").
    b) Include the building name or number if the source is in another building.
5) Fourth line: Date installed (e.g., “INSTALLED JULY 20xx”).

4. Safety switches, separately mounted circuit breakers and motor starters, VFD’s, etc.:
    a. Tag type: Type C - Phenolic Name Plates.
    b. Fastener: Screws.
    c. Legend:
        1) Letter height: 1/4 IN minimum.
        2) First line: Description of load equipment is connected to (e.g., "PUMP Pxxx").
        3) Second line:
            a) Source of power (e.g., "FED FROM MCCxxx LOCATED IN ROOM xxx").
            b) The source of power room number is only required when there are multiple electrical rooms, if the source is in another building, the building name or number shall be used.
5. Enclosure for instrumentation and control equipment, (e.g., lighting control panels, etc.):
    a. Tag type: Type C - Phenolic Name Plates.
    b. Fastener: Screws.
    c. Legend:
        1) Letter height: 1/2 IN minimum.
        2) Equipment name (e.g., "LIGHTING CONTROL PANEL LCPxxx").
6. Components inside equipment enclosures (e.g., circuit breakers, fuses, control power transformers, control relays, contactors, timers, etc.):
    a. Tag type: Type D - Self-Adhesive Tape Tags and Signs.
    b. Fastener: Self.
    c. Legend:
        1) Letter height: 3/16 IN minimum.
        2) Description or function of component (e.g., "M-xxx”, “CR-xxx” or “TR-xxx").
7. Through enclosure door mounted equipment (e.g., selector switches, controller digital displays, etc.):
    a. Tag type: Type C - Phenolic Name Plates.
    b. Fastener: Screws.
    c. Legend:
        1) Letter height: 1/4 IN minimum.
        2) Component tag number as indicated on the Drawings or as defined by contractor (e.g., “HS-xxx”).
8. Conductors in control panels and in pull or junction boxes where multiple circuits exist.
    a. Tag type: Type D - Self-Adhesive Tape Tags.
    b. Fastener: Self.
    c. Tag conductor at both ends.
    d. Legend:
        1) Letter height: 1/8 IN minimum.
        2) Circuit number or wire number as scheduled on the Drawings or as furnished with the equipment.
9. Conductors in handholes and manholes.
    a. Tag type: Type A3 - Metal Tape Tags.
    b. Fastener: Nylon strap.
    c. Tag conductor at both ends.
    d. Legend:
        1) Letter height: 1/8 IN minimum.
        2) Circuit number or wire number as scheduled on the Drawings.
10. Grounding conductors associated with grounding electrode system in accordance with the following:
    a. Tag type: Type D - Self-Adhesive Tape Tags.
    b. Fastener: Self.

c. Legend:
    1) Letter height: 1/8 IN minimum.
    2) Function of conductor (e.g., "MAIN BONDING JUMPER", "TO GROUND RING", "TO MAIN WATER PIPE").

11. Flash protection for switchboards, panelboards, industrial control panels and motor control centers:
    a. Tag type: Type D - Self-Adhesive Tape Signs.
    b. Fastener: Self.
    c. Legend: Per NFPA 70.
12. Equipment where more than one voltage source is present:
    a. Tag type:
        1) Type B2 - Nonmetallic Signs.
        2) Type D - Self-Adhesive Tape Signs.
    b. Fastener:
        1) Screw or adhesive.
        2) Self.
    c. Size: 1-3/4 IN x 2-1/2 IN.
    d. Location: Exterior face of enclosure or cubical.
    e. Legend:
        1) OSHA Danger Sign.
        2) Description of Danger: “MULTIPLE VOLTAGE SOURCES”.

END OF SECTION

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DIVISION 26

ELECTRICAL

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SECTION 26 05 00
ELECTRICAL - BASIC REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Basic requirements for electrical systems.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Division 03 - Concrete.
   4. Section 10 14 00 - Identification Devices.
   5. Section 26 05 19 - Wire and Cable - 600 Volt and Below.
   6. Section 26 05 33 - Raceways and Boxes.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Aluminum Association (AA):
      a. ADM, Aluminum Design Manual.
   2. American Institute of Steel Construction (AISC):
      a. Steel Construction Manual.
   3. American National Standards Institute (ANSI).
   4. ASTM International (ASTM):
      a. A36/A36M, Standard Specification for Carbon Structural Steel.
      b. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
      c. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   5. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. C2, National Electrical Safety Code (NESC).
   6. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   7. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   8. Underwriters Laboratories, Inc. (UL).

B. Products to be listed by a Nationally Recognized Testing Laboratory (NRTL) in accordance with applicable product standards.
   1. Applicable product standards including, but not limited to, ANSI, FM, IEEE, NEMA and UL.
   2. NRTL includes, but is not limited to, CSA Group Testing and Certification (CS), FM Approvals LLC (FM), Intertek Testing Services NA, Inc. (ETL), and Underwriters Laboratories, Inc. (UL).

1.3 DEFINITIONS

A. For the purposes of providing materials and installing electrical work the following definitions shall be used.
   1. Outdoor area: Exterior locations where the equipment is normally exposed to the weather and including below grade structures, such as vaults, manholes, handholes and in-ground pump stations.
   2. Shop fabricated: Manufactured or assembled equipment for which a UL test procedure has not been established.

1.4 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of submittal process.
   2. General requirements:
      a. Provide manufacturer's technical information on products to be used, including product descriptive bulletin.
      b. Include data sheets that include manufacturer's name and product model number.
         1) Clearly identify all optional accessories.
      c. Acknowledgement that products are NRTL listed or are constructed utilizing NRTL recognized components.
      d. Manufacturer's delivery, storage, handling and installation instructions.
      e. Product installation details.
      f. Short Circuit Current Rating (SCCR) nameplate marking per NFPA 70, include any required calculations.
      g. See individual specification sections for any additional requirements.
   3. Fabrication and/or layout drawings:
      a. Concrete and reinforcing steel, per Division 03 requirements.

B. Operation and Maintenance Manuals:
   1. See Specification Section 01 33 04 for requirements for:
      a. The mechanics and administration of the submittal process.
      b. The content process of Operation and Maintenance Manuals.

C. When a Specification Section includes products specified in another Specification Section, each Specification Section shall have the required Shop Drawing transmittal form per Specification Section 01 33 00 and all Specification Sections shall be submitted simultaneously.

1.5 DELIVERY, STORAGE, AND HANDLING

A. See Specification Section 01 65 50.

B. Protect nameplates on electrical equipment to prevent defacing.

C. Provide All equipment with lamacoid labels with the equipment label as labeled on the drawings.

1.6 AREA DESIGNATIONS

A. Designation of an area will determine the NEMA rating of the electrical equipment enclosures, types of conduits and installation methods to be used in that area.
   1. Outdoor areas:
      a. Wet.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, refer to specific Electrical Specification Sections and specific material paragraphs below for acceptable manufacturers.

B. Provide all components of a similar type by one (1) manufacturer.

2.2 MATERIALS

A. Electrical Equipment Support Pedestals and/or Racks:
   1. Manufacturers:
      a. Modular strut:
         1) Unistrut Building Systems.
         2) B-Line by Eaton.

3) Globe Strut.
4) Superstrut by Thomas & Betts.

2. Material requirements:
   a. Modular strut:
      1) Galvanized steel: ASTM A123/123M or ASTM A153/A153M.
      2) Stainless steel: AISI Type 316.
      3) PVC coated galvanized steel: ASTM A123/A123M or ASTM A153/A153M and 20 MIL PVC coating.
      4) Aluminum: AA Type 6063-T6.
   b. Structural members (e.g., I beams, L and C channels):
      1) Galvanized steel: ASTM A36/A36M steel with galvanizing per ASTM A123/A123M.
      2) Aluminum: AA Type 6061-T6 or 6063-T6.
   c. Mounting hardware:
      1) Galvanized steel.
      2) Stainless steel.
   d. Concrete and reinforcing steel: See Division 03 specifications.

B. Equipment pads (interior and exterior):
   1. Install per drawings and contract documents.
   2. Concrete and reinforcing steel: See Division 03 specifications

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install and wire all equipment, including prepurchased equipment, and perform all tests necessary to assure conformance to the Drawings and Specification Sections and ensure that equipment is ready and safe for energization.

B. Install equipment in accordance with the requirements of:
   1. NFPA 70.
   2. IEEE C2.
   3. The manufacturer's instructions.

C. In general, conduit routing is shown on the Drawings.
   1. The Contractor is responsible for routing all conduits including those shown on one-line and control block diagrams and home runs shown on floor plans.
   2. Conduit routings and stub-up locations that are shown are approximate; exact routing to be as required for equipment furnished and field conditions.

D. Do not use equipment that exceed dimensions or reduce clearances indicated on the Drawings or as or required by the NFPA 70.

E. Install equipment plumb, square and true with construction features and securely fastened.

F. Install electrical equipment, including pull and junction boxes, minimum of 6 IN from process, gas, air and water piping and equipment.

G. Install equipment so it is readily accessible for operation and maintenance, is not blocked or concealed and does not interfere with normal operation and maintenance requirements of other equipment.

H. Device Mounting Schedule:
   1. Unless indicated otherwise on the Drawings, mounting heights are as indicated below:
      a. Safety switch (to center of operating handle): 54 IN.
      b. Panelboard (to top): 72 IN.

I. Avoid interference of electrical equipment operation and maintenance with structural members, building features and equipment of other trades.

1. When it is necessary to adjust the intended location of electrical equipment, unless specifically dimensioned or detailed, the Contractor may make adjustments of up to 6 IN in equipment location with the Engineer's approval.

J. Provide electrical equipment support system per the following area designations:
   1. Wet areas:
      a. Galvanized system consisting of galvanized steel channels and fittings, nuts and hardware.
      b. Field touch-up cut ends and scratches of galvanized components with the specified primer during the installation, before rust appears.

K. Provide all necessary anchoring devices and supports rated for the equipment load based on dimensions and weights verified from approved submittals, or as recommended by the manufacturer.
   1. Do not cut, or weld to, building structural members.
   2. Do not mount safety switches or other equipment to equipment enclosures, unless enclosure mounting surface is properly braced to accept mounting of external equipment.
   3. Refer to drawings for all anchoring device and support rack details.

L. Provide non-metallic corrosion resistant spacers to maintain 1/4 IN separation between metallic equipment and/or metallic equipment supports and mounting surface in wet areas, on below grade walls and on walls of liquid containment or processing areas such as Basins, Clarifiers, Digesters, Reservoirs, etc.

M. Do not place equipment fabricated from aluminum in direct contact with earth or concrete.

N. Screen or seal all openings into equipment mounted outdoors to prevent the entrance of rodents and insects.

O. Do not use materials that may cause the walls or roof of a building to discolor or rust.

P. Provide field markings and/or documentation of available short-circuit current (available fault current) and related information for equipment as required by the NFPA 70 and other applicable codes.

Q. Provide equipment or control panels with Short Circuit Current Rating (SCCR) labeling as required by NFPA 70 and other applicable codes.
   1. Determine the SCCR rating by one of the following methods:
      a. Method 1: SCCR rating meets or exceeds the available fault current of the source equipment when indicated on the Drawings.
      b. Method 2: SCCR rating meets or exceeds the source equipment's Amp Interrupting Current (AIC) rating as indicated on the Drawings.
      c. Method 3: SCCR rating meets or exceeds the calculated available short circuit current at the control panel.
   2. The source equipment is the switchboard, panelboard, motor control center or similar equipment where the equipment or control panel circuit originates.
   3. For Method 3, provide calculations justifying the SCCR rating. Utilize source equipment available fault current or AIC rating as indicated on the Drawings.

3.2 FIELD QUALITY CONTROL

A. Verify exact rough-in location and dimensions for connection to electrified equipment, provided by others.

B. Replace equipment and systems found inoperative or defective and re-test.

C. Cleaning:
   1. See Specification Section 01 74 00.

D. The protective coating integrity of support structures and equipment enclosures shall be maintained.
   1. Repair galvanized components utilizing a zinc rich paint.

2. Repair painted components utilizing touch up paint provided by or approved by the manufacturer.
3. Repair PVC coated components utilizing a patching compound, of the same material as the coating, provided by the manufacturer of the component.
4. Repair surfaces which will be inaccessible after installation prior to installation.
5. See Specification Section 26 05 33 for requirements for conduits and associated accessories.

E. Replace nameplates damaged during installation.

END OF SECTION

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SECTION 26 05 19

WIRE AND CABLE - 1000 VOLT AND BELOW

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Material and installation requirements for:
      a. Power cable.
      b. Wire connectors.
      c. Insulating tape.
      d. Pulling lubricant.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Section 26 05 00 - Electrical - Basic Requirements.
   4. Section 26 08 13 - Acceptance Testing.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
      a. ASTM International (ASTM):B3
      b. B8.
   2. Insulated Cable Engineers Association (ICEA):
      a. S-58-679, Standard for Control Cable Conductor Identification.
   3. National Electrical Manufacturers Association (NEMA):
      a. ICS 4, Industrial Control and Systems: Terminal Blocks.
   4. National Electrical Manufacturers Association/Insulated Cable Engineers Association (NEMA/ICEA):
      a. WC 57/S-73-532, Standard for Control Cables.
      b. WC 70/S-95-658, Non-Shielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
   5. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
      b. 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
   6. Telecommunications Industry Association/Electronic Industries Alliance/American National Standards Institute (TIA/EIA/ANSI):
      a. 568, Commercial Building Telecommunications Cabling Standard.
   7. Underwriters Laboratories, Inc. (UL):
      a. 44, Standard for Safety Thermoset-Insulated Wires and Cables.
      b. 83, Standard for Safety Thermoplastic-Insulated Wires and Cables.
      c. 467, Standard for Safety Grounding and Bonding Equipment.
      d. 486A, Standard for Safety Wire Connectors and Soldering Lugs for use with Copper Conductors.
      e. 486C, Standard for Safety Splicing Wire Connections.
      f. 510, Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape.
      g. 1277, Standard for Safety Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
      h. 1581, Standard for Safety Reference Standard for Electrical Wires, Cables, and Flexible Cords.
      i. 2250, Standard for Safety Instrumentation Tray Cable.

1.3 DEFINITIONS

A. Cable: Multi-conductor, insulated, with outer sheath containing either building wire or instrumentation wire.

B. Power Cable: Multi-conductor, insulated, with outer sheath containing building wire, No. 8 AWG and larger.

C. Control Cable: Multi-conductor, insulated, with outer sheath containing building wires, No. 14, No. 12 or No. 10 AWG.

D. Building Wire: Single conductor, insulated, with or without outer jacket depending upon type.

E. Digital Cable: CAT6 ethernet cable

F. DC Power Cable: Single conductor, insulated at 1000 Volts, copper conductors, XHHW-2

1.4 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data:
      a. Provide submittal data for all products specified in PART 2 of this Specification Section except:
         1) Wire connectors.
         2) Insulating tape.
         3) Cable lubricant.
      b. See Specification Section 26 05 00 for additional requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

A. See Specification Section 26 05 00.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Building wire, power, DC Power, and control cable :
      a. Aetna Insulated Wire.
      b. Alphawire.
      c. Cerrowire.
      d. Encore Wire Corporation.
      e. General Cable.
      f. Okonite Company.
      g. Southwire Company.
   2. Wire connectors:
      a. Burndy Corporation.
      b. Buchanan.
      c. Ideal.
      d. Ilsco.
      e. 3M Co.
      f. Teledyne Penn Union.
      g. Thomas and Betts.
      h. Phoenix Contact.
   3. Insulating and color coding tape:
      a. 3M Co.

b. Plymouth Bishop Tapes.
c. Red Seal Electric Co.

2.2 MANUFACTURED UNITS

A. Building Wire:
1. Conductor shall be copper with 1000 V rated insulation.
2. Conductors shall be stranded, except for conductors used in lighting and receptacle circuits which may be stranded or solid.
3. Surface mark with manufacturer's name or trademark, conductor size, insulation type and UL label.
4. Conform to NEMA/ICEA WC 70/S-95-658 and UL 83 for type THHN/THWN and THHN/THWN-2 insulation.
5. Conform to ASTM-B3, B8, NEMA/ICEA WC 70/S-95-658 and UL 44 for type XHHW-2 insulation.

B. Power Cable:
1. Conductor shall be copper with 1000 V rated insulation.
2. Surface mark with manufacturer's name or trademark, conductor size, insulation type and UL label.
3. Conform to NEMA/ICEA WC 70/S-95-658 and UL 83 and UL 1277 for type THHN/THWN insulation with an overall PVC jacket.
4. Conform to NEMA/ICEA WC 70/S-95-658 and UL 44 and UL 1277 for type XHHW-2 insulation with an overall PVC jacket.
5. Number of conductors as required, including a bare ground conductor.
6. Individual conductor color coding:
   a. ICEA S-58-679, Method 4.
   b. See PART 3 of this Specification Section for additional requirements.
7. Conform to NFPA 70 Type TC ..

C. DC Power Cable:
1. Conductor shall be copper with 1000 V rated insulation.
2. Surface mark with manufacturer's name or trademark, conductor size, insulation type and UL label.
3. Conform to NEMA/ICEA WC 70/S-95-658 and UL 44 for type XHHW-2 insulation with an overall Cross-linked Polyethylene (XLPE).
4. Individual conductor color coding:
   a. ICEA S-58-679, Method 4.
   b. See PART 3 of this Specification Section for additional requirements.
5. Conform to NFPA 70 Type XHHW-2.

D. Electrical Equipment Control Wire:
1. Conductor shall be copper with 600 V rated insulation.
2. Conductors shall be stranded.
3. Surface mark with manufacturer's name or trademark, conductor size, insulation type and UL label.
4. Conform to UL 44 for Type SIS insulation.
5. Conform to UL 83 for Type MTW insulation.

E. Instrumentation Cable:
1. Digital Cable(ethernet between chargers):
   a. As recommended by equipment (e.g., Charger) manufacturer.
   b. Horizontal voice and data cable:
      1) Category 6 per TIA/EIA/ANSI 568.
      2) Cable shall be label-verified.
      3) Cable jacket shall be factory marked at regular intervals indicating verifying organization and performance level.
      4) Conductors: No. 24 AWG solid untinned copper.

5) Rated CMP per NFPA 70.
c. Conform to] NFPA 262 and NFPA 70 Type ITC.

F. Wire Connectors:
1. Twist/screw on type:
a. Insulated pressure or spring type solderless connector.
b. 1000 V rated.
c. Ground conductors: Conform to UL 486C and/or UL 467 when required by local codes.
d. Phase and neutral conductors: Conform to UL 486C.
2. Compression and mechanical screw type:
a. 1000 V rated.
b. Ground conductors: Conform to UL 467.
c. Phase and neutral conductors: Conform to UL 486A.
3. Terminal block type:
a. High density, screw-post barrier-type with white center marker strip.
b. 1000 V and ampere rating as required, for power circuits.
c. 600 V, 20 ampere rated for control circuits.
d. 300 V, 15 ampere rated for instrumentation circuits.
e. Conform to NEMA ICS 4 and UL 486A.

G. Insulating and Color Coding Tape:
1. Pressure sensitive vinyl.
2. Premium grade.
3. Heat, cold, moisture, and sunlight resistant.
4. Thickness, depending on use conditions: 7, 8.5, or 10 MIL.
5. For cold weather or outdoor location, tape must also be all-weather.
6. Color:
a. Insulating tape: Black.
b. Color coding tape: Fade-resistant color as specified herein.
7. Comply with UL 510.

H. Pulling Lubricant: Cable manufacturer's standard containing no petroleum or other products which will deteriorate insulation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Permitted Usage of Insulation Types:
1. Type XHHW-2:
a. Building wire and power and control cable in conduit in outdoor areas and below grade.
b. Building wire and power and control cable in cable tray in outdoor areas.
c. DC circuit between paired Chargepoint Chargers. Per manufacturer’s recommendations this insulation shall be required.
2. Type THHN/THWN and THHN/THWN-2:
a. Exterior underground feeder circuit as required in the drawings and documentation.
3. Type SIS and MTW:
a. For the wiring of control equipment within control panels and field wiring of control equipment within switchgear, switchboards, motor control centers.

B. Conductor Size Limitations:
1. Feeder and branch power conductors shall not be smaller than No. 12 AWG unless otherwise indicated on the Drawings.
2. Control conductors shall not be smaller than No. 14 AWG unless otherwise indicated on the Drawings.
3. Instrumentation conductors shall not be smaller than No. 18 AWG unless otherwise indicated on the Drawings.

C. Color Code All Wiring as Follows:
   1. Building wire:

	240 V, 208 V, 240/120 V, 208/120 V	480 V, 480/277 V
Phase 1	Black	Brown
Phase 2	Red *	Orange
Phase 3	Blue	Yellow
Neutral	White	White or Gray
Ground	Green	Green

* Orange when it is a high leg of a 120/240 V Delta system.

      a. Conductors larger than No. 6 AWG:
         1) Insulated phase and neutral conductors shall be identified by one of the following methods:
            a) Continuous colored outer finish along its entire length.
            b) 3 IN of colored tape applied at the termination.
         2) Insulated grounding conductor shall be identified by one of the following methods:
            a) Continuous green outer finish along its entire length.
            b) Stripping the insulation from the entire exposed length.
            c) Using green tape to cover the entire exposed length.
         3) The color coding shall be applied at all accessible locations, including but not limited to: Junction and pull boxes, wireways, manholes and handholes.
   2. Power cables ICEA S-58-679, Method 4 with:
      a. Phase and neutral conductors identified with 3 IN of colored tape, per the Table herein, applied at the terminations.
      b. Ground conductor: Bare.
   3. Control cables ICEA S-58-679, Method 1, Table E-2:
      a. When a bare ground is not provided, one of the colored insulated conductors shall be re-identified by stripping the insulation from the entire exposed length or using green tape to cover the entire exposed length.
      b. When used in power applications the colored insulated conductors used as phase and neutral conductors may have to be re-identified with 3 IN of colored tape, per the Table herein, applied at the terminations.

D. Install all wiring in raceway unless otherwise indicated on the Drawings.

E. Color Coding Tape Usage: For color coding of conductors.

3.2 FIELD QUALITY CONTROL

A. Acceptance Testing:
   1. See Specification Section 26 08 13.

END OF SECTION

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SECTION 26 05 26
GROUNDING AND BONDING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Material and installation requirements for grounding and bonding system(s).

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Section 10 14 00 - Identification Devices.
   4. Section 26 05 00 - Electrical - Basic Requirements.
   5. Section 26 05 19 - Wire and Cable - 1000 Volt and Below.
   6. Section 26 05 33 - Raceways and Boxes.
   7. Section 26 08 13 - Acceptance Testing.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. ASTM International (ASTM):
      a. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
   2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. 837, Standard for Qualifying Permanent Connections Used in Substation Grounding.
   3. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   4. Underwriters Laboratories, Inc. (UL):
      a. 467, Grounding and Bonding Equipment.

B. Assure ground continuity is continuous throughout the entire Project.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data.
      a. Provide submittal data for all products specified in PART 2 of this Specification Section except:
         1) Grounding clamps, terminals and connectors.
         2) Exothermic welding system.
      b. See Specification Section 26 05 00 for additional requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Ground rods and bars and grounding clamps, connectors and terminals:
      a. ERICO by Pentair.
      b. Harger Lightning & Grounding.
      c. Heary Bros. Lightning Protection Co. Inc..
      d. Burndy by Hubbell.

e. Robbins Lightning, Inc.
f. Blackburn by Thomas & Betts.
g. Thompson Lightning Protection, Inc.

2. Exothermic weld connections:
   a. ERICO by Pentair - Cadweld.
   b. Harger Lightning & Grounding - Ultraweld.
   c. Burndy by Hubbell - Thermoweld.
   d. FurseWELD by Thomas & Betts.

2.2 COMPONENTS

A. Wire and Cable:
   1. Bare conductors: Soft drawn stranded copper meeting ASTM B8.
   2. Insulated conductors: Color coded green, per Specification Section 26 05 19.

B. Conduit: As specified in Specification Section 26 05 33.

C. Ground Bars:
   1. Solid copper:
      a. 1/4 IN thick.
      b. 2 or 4 IN wide.
      c. 24 IN long minimum in main service entrance electrical rooms, 12 IN long elsewhere.
   2. Predrilled grounding lug mounting holes.
   3. Stainless steel or galvanized steel mounting brackets.
   4. Insulated standoffs.

D. Ground Rods:
   1. 5/8 IN x 10 FT.
   2. Copper-clad:
      a. 10 MIL minimum uniform coating of electrolytic copper molecularly bonded to a rigid steel core.
      b. Corrosion resistant bond between the copper and steel.
      c. Hard drawn for a scar-resistant surface.

E. Grounding Clamps, Connectors and Terminals:
   1. Mechanical type:
      a. Standards: UL 467.
      b. High copper alloy content.
   2. Compression type for interior locations:
      a. Standards: UL 467.
      b. High copper alloy content.
      c. Non-reversible.
      d. Terminals for connection to bus bars shall have two bolt holes.
   3. Compression type suitable for direct burial in earth or concrete:
      a. Standards: UL 467, IEEE 837.
      b. High copper alloy content.
      c. Non-reversible.
      d. Factory filled with oxide inhibiting compound.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:
   1. Install products in accordance with manufacturer's instructions.
   2. Size grounding conductors and bonding jumpers in accordance with NFPA 70, Article 250, except where larger sizes are indicated on the Drawings.

3. Remove paint, rust, or other non-conducting material from contact surfaces before making ground connections. After connection, apply manufacturers approved touch-up paint to protect metallic surface from corrosion.
4. Do not splice grounding electrode conductors except at ground rods.
5. Install ground rods and grounding electrode conductors in undisturbed, firm soil.
    a. Provide excavation required for installation of ground rods and conductors.
    b. Use driving studs or other suitable means to prevent damage to threaded ends of sectional rods.
    c. Unless otherwise specified, connect conductors to ground rods with compression type connectors or exothermic weld.
    d. Provide sufficient slack in conductor to prevent conductor breakage during backfill or due to ground movement.
    e. Backfill excavation completely, thoroughly tamping to provide good contact between backfill materials and ground rods and conductors.
6. Do not use exothermic welding if it will damage the structure the grounding conductor is being welded to.

B. Grounding Electrode System:
1. Provide a grounding electrode system in accordance with NFPA 70, Article 250 and as indicated on the Drawings.
    a. All grounding electrode conductors terminate on a main ground bar located adjacent to the service entrance equipment.
2. Grounding electrode conductor terminations:
    a. Ground bars in electrical equipment: Use compression type conductor terminal and bolt it to the ground bar or manufacture's provided mechanical type termination device.
    b. Ground rod: Compression type or exothermic weld, unless otherwise specified.
    c. At all above grade terminations, the conductors shall be labeled per Specification Section 10 14 00.
3. Ground ring grounding system:
    a. Ground ring consists of ground rods and a conductor looped around the Switchgear and Transformer pads. Refer to drawing for approximate location.
    b. Placed at a minimum of 10 FT from the equipment pads and 2 FT-6 IN below grade.
    c. Provide a minimum of four ground rods placed at the corners of the structure and additional rods so that the maximum distance between ground rods does not exceed 50 FT.
    d. Grounding conductor: Bare conductor, size as indicated on the Drawings.
    e. Ground rod test stations:
        1) Provided where indicated on the Drawings.
        2) Grounding conductors connected to ground rod with removable ground clamps.

C. Raceway Bonding/Grounding:
1. Install all metallic raceway so that it is electrically continuous.
2. Provide an equipment grounding conductor in all raceways with insulation identical to the phase conductors, unless otherwise indicated on the Drawings.
3. NFPA 70 required grounding bushings shall be of the insulating type.
4. Provide double locknuts at all panels.
5. Bond all conduits, at entrance and exit of equipment, to the equipment ground bus or lug.
6. Provide bonding jumpers if conduits are installed in concentric knockouts.
7. Make all metallic raceway fittings and grounding clamps tight to ensure equipment grounding system will operate continuously at ground potential to provide low impedance current path for proper operation of overcurrent devices during possible ground fault conditions.

D. Equipment Grounding:
1. Ground all utilization equipment with an equipment grounding conductor.
2. Provide separate grounding conductors bonded to the ground grid for all DC equipment.

3. Use generator manufacturer's provisions for grounding electric generators, or manufacturer's written instructions, except as shown on the Drawings.

E. Manhole and Handhole Grounding:
   1. Provide a ground rod and ground bar, when indicated or as needed, in each manhole and handhole with exposed metal parts.
      a. Expose a minimum of 4 IN of the rod above the floor for field connections to the rod.
   2. Connect all exposed metal parts (e.g., conduits and cable racks) to the ground rod.

F. Fence Grounding Conductor:
   1. Provide separate bare copper ground conductor as part of the concrete ductbank, connected to the grounding system.
   2. Connect fencing to ground conductor as indicated on drawings.

3.2 FIELD QUALITY CONTROL

A. Leave grounding system uncovered until observed by Owner.

B. Acceptance testing:
   1. See Specification Section 26 08 13.

C. Provide a continuity test on the components of the grounding electrode system.

D. Complete grounding system: Resistance of 5 ohms or less.

E. Test resistance of installed ground system after backfilling and before connection to any other grounded system including underground piping, utility services or other building ground systems.
   1. Test ground grid resistance by fall-of-potential method.
   2. Perform test at the ground rod test station.

END OF SECTION

SECTION 26 05 33
RACEWAYS AND BOXES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Material and installation requirements for:
      a. Conduits.
      b. Conduit fittings.
      c. Conduit supports.
      d. Wireways.
      e. Pull and junction boxes.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Section 26 05 00 - Electrical - Basic Requirements.
   4. Section 26 05 43 - Electrical - Exterior Underground.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Aluminum Association (AA).
   2. American Iron and Steel Institute (AISI).
   3. ASTM International (ASTM):
      a. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
      b. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
      c. D2564, Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
   4. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. RN 1, Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
      c. TC 2, Electrical Polyvinyl Chloride (PVC) Tubing and Conduit.
      d. TC 3, Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
      e. TC 14.AG, Aboveground Reinforced Thermosetting Resin Conduit and Fittings.
      f. TC 14.BG, Belowground Reinforced Thermosetting Resin Conduit and Fittings.
   5. National Electrical Manufacturers Association/American National Standards Institute (NEMA/ANSI):
      a. C80.1, Electric Rigid Steel Conduit (ERSC).
      b. C80.3, Steel Electrical Metallic Tubing (EMT).
      c. C80.5, Electrical Aluminum Rigid Conduit (ERAC).
      d. OS 1, Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports.
   6. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   7. Underwriters Laboratories, Inc. (UL):
      a. 1, Standard for Flexible Metal Conduit.
      b. 6, Electrical Rigid Metal Conduit - Steel.
      c. 50, Enclosures for Electrical Equipment, Non-Environmental Considerations.
      d. 360, Standard for Liquid-Tight Flexible Metal Conduit.
      e. 467, Grounding and Bonding Equipment.
      f. 514A, Metallic Outlet Boxes.

g. 514B, Conduit, Tubing, and Cable Fittings.
h. 651, Standard for Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings.
i. 797, Electrical Metallic Tubing - Steel.
j. 870, Standard for Wireways, Auxiliary Gutters, and Associated Fittings.
k. 1203, Standard for Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations.
l. 2420, Belowground Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
m. 2515, Aboveground Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.

1.3 SUBMITTALS

A. Shop Drawings:
1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
2. Product technical data:
a. Provide submittal data for all products specified in PART 2 of this Specification Section except:
1) Conduit fittings.
2) Support systems.
b. See Specification Section 26 05 00 for additional requirements.
3. Fabrication and/or layout drawings:
a. Identify dimensional size of pull and junction boxes to be used.

1.4 DELIVERY, STORAGE, AND HANDLING

A. See Specification Section 26 05 00.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
1. Rigid metal conduits and electrical metallic tubing:
a. Allied Tube and Conduit.
b. Western Tube and Conduit Corporation.
c. Wheatland Tube.
d. Patriot Aluminum Products, LLC.
2. PVC coated rigid metal conduits:
a. Ocal by Thomas & Betts.
b. Robroy Industries.
3. Rigid nonmetallic conduit:
a. Prime Conduit.
b. Cantex, Inc.
c. Osburn Associates, Inc.
4. Flexible conduit:
a. AFC Cable Systems.
b. Anamet, Inc.
c. Electri-Flex Company.
d. International Metal Hose Company.
e. Southwire Company, LLC.
5. Conduit fittings and accessories:
a. Appleton by Emerson Electric Co.
b. Carlon by Thomas & Betts.
c. Cantex, Inc.
d. Crouse-Hinds by Eaton.
e. Killark by Hubbell.
f. Osburn Associates, Inc.

g. O-Z/Gedney by Emerson Electric Co.
h. Raco by Hubbell.
i. Steel City by Thomas & Betts.
j. Thomas & Betts.

6. Support systems:
   a. Unistrut by Atkore International, Inc.
   b. B-Line by Eaton.
   c. Kindorf by Thomas & Betts.
   d. Minerallac Company.
   e. CADDY by Pentair.
   f. Superstrut by Thomas & Betts.
7. Pull and junction boxes:
   a. Appleton by Emerson Electric Co.
   b. Crouse-Hinds by Eaton
   c. Killark by Hubbell.
   d. O-Z/Gedney by Emerson Electric Co.
   e. Steel City by Thomas & Betts.
   f. Raco by Hubbell
   g. Bell by Hubbell.
   h. Hoffman Engineering.
   i. Wiegmann by Hubbell.
   j. B-Line by Eaton.
   k. Adalet.
   l. RITTAL North America LLC.
   m. Stahlin by Robroy Enclosures.

2.2 RIGID METAL CONDUITS

A. Rigid Galvanized Steel Conduit (RGS):
   1. Mild steel with continuous welded seam.
   2. Metallic zinc applied by hot-dip galvanizing or electro-galvanizing.
   3. Threads galvanized after cutting.
   4. Internal coating: Baked lacquer, varnish or enamel for a smooth surface.
   5. Standards: NFPA 70 Type RMC, NEMA/ANSI C80.1, UL 6.

B. PVC-Coated Rigid Steel Conduit (PVC-RGS):
   1. Nominal 40 MIL Polyvinyl Chloride Exterior Coating:
      a. Coating: Bonded to hot-dipped galvanized rigid steel conduit conforming to NEMA/ANSI C80.1.
      b. The bond between the PVC coating and the conduit surface: Greater than the tensile strength of the coating.
   2. Nominal 2 mil, minimum, urethane interior coating.
   3. Urethane coating on threads.
   4. Conduit: Epoxy prime coated prior to application of PVC and urethane coatings.
   5. Female Ends:
      a. Have a plastic sleeve extending a minimum of one pipe diameter or 2 IN, whichever is less beyond the opening.
      b. The inside diameter of the sleeve shall be the same as the outside diameter of the conduit to be used with it.
   6. Standards: NFPA 70 Type RMC, NEMA/ANSI C80.1, UL 6, NEMA RN 1.

C. Rigid Aluminum Conduit (RAC):
   1. AA Type 6063 aluminum alloy, T-1 temper.
   2. Maximum copper content of 0.10 PCT.
   3. Extruded, seamless.
   4. Standards: NFPA 70 Type RMC, NEMA/ANSI C80.5, UL 6.

2.3 RIGID NONMETALLIC CONDUIT

A. Schedules 40 (PVC-40) and 80 (PVC-80):
   1. Polyvinyl-chloride (PVC) plastic compound which includes inert modifiers to improve weatherability and heat distribution.
   2. Rated for direct sunlight exposure.
   3. Fire retardant and low smoke emission.
   4. Shall be suitable for use with 90 DEGC wire and shall be marked "maximum 90 DEGC".
   5. Standards: NFPA 70 Type PVC, NEMA TC 2, UL 651.

2.4 FLEXIBLE CONDUIT

A. Coilable Conduit:
   1. Extruded from virgin High Density Polyethylene (HDPE) resin, in accordance to the requirements of ASTM D3350 with cell classification 345440C.
   2. Stabilized against thermal and UV degradation.
   3. Conduit to be of a continuous length, smooth walled with a low friction internal surface containing no welds or joints and coiled on a reel.
   4. Dimensions: Schedule 40 or 80 or TC-7.
   5. Suitable for the following installation methods: Directional bore.
   6. The conduit to be provided:
      a. Containing a pull string.
   7. Conduit color:
      a. Power applications: Black.
   8. Standards: NFPA 70 Type HDPE, ASTM D3350, ASTM D3485, UL 651A.

2.5 CONDUIT FITTINGS AND ACCESSORIES

A. Fittings for Use with RGS :
   1. General:
      a. In hazardous locations listed for use in Class I, Groups C and D locations.
   2. Locknuts:
      a. Threaded steel or malleable iron.
      b. Gasketed or non-gasketed.
      c. Grounding or non-grounding type.
   3. Bushings:
      a. Threaded, insulated metallic.
      b. Grounding or non-grounding type.
   4. Hubs: Threaded, insulated and gasketed metallic for raintight connection.
   5. Couplings:
      a. Threaded straight type: Same material and finish as the conduit with which they are used on.
      b. Threadless type: Gland compression or self-threading type, concrete tight.
   6. Unions: Threaded galvanized steel or zinc plated malleable iron.
   7. Conduit bodies (ells and tees):
      a. Body: Zinc plated cast iron or cast copper free aluminum with threaded hubs.
      b. Standard and mogul size.
      c. Cover:
         1) Clip-on type with stainless steel screws.
         2) Gasketed or non-gasketed galvanized steel, zinc plated cast iron or cast copper free aluminum.
   8. Conduit bodies (round):
      a. Body: Zinc plated cast iron or cast copper free aluminum with threaded hubs.
      b. Cover: Threaded screw on type, gasketed, galvanized steel, zinc plated cast iron or cast copper free aluminum.
   9. Sealing fittings:
      a. Body: Zinc plated cast iron or cast copper free aluminum with threaded hubs.
      b. Standard and mogul size.

c. With or without drain and breather.
d. Fiber and sealing compound: UL listed for use with the sealing fitting.

10. Service entrance head:
    a. Malleable iron, galvanized steel or copper free aluminum.
    b. Insulated knockout cover for use with a variety of sizes and number of conductors.
11. Expansion couplings:
    a. 2 IN nominal straight-line conduit movement in either direction.
    b. Galvanized steel with insulated bushing.
    c. Gasketed for wet locations.
    d. Internally or externally grounded.
12. Expansion/deflection couplings:
    a. 3/4 IN nominal straight-line conduit movement in either direction.
    b. 30 DEG nominal deflection from the normal in all directions.
    c. Metallic hubs, neoprene outer jacket and stainless steel jacket clamps.
    d. Internally or externally grounded.
    e. Watertight, raintight and concrete tight.
13. Standards: UL 467, UL 514B, UL 1203.

B. Fittings for Use with PVC-RGS:
1. The same material and construction as those fittings listed under paragraph "Fittings for Use with RGS “and coated as defined under paragraph "PVC Coated Rigid Steel Conduit (PVC-RGS)."

C. Fittings for Use with Rigid Nonmetallic PVC Conduit:
1. Coupling, adapters and conduit bodies:
    a. Same material, thickness, and construction as the conduits with which they are used.
    b. Homogeneous plastic free from visible cracks, holes or foreign inclusions.
    c. Bore smooth and free of blisters, nicks or other imperfections which could damage the conductor.
2. Solvent cement for welding fittings shall be supplied by the same manufacturer as the conduit and fittings.
3. Standards: ASTM D2564, NEMA TC 3, UL 651, UL 514B.

D. Weather and Corrosion Protection Tape:
1. PVC based tape, 10 mils thick.
2. Protection against moisture, acids, alkalis, salts and sewage and suitable for direct bury.
3. Used with appropriate pipe primer.

2.6 ALL RACEWAY AND FITTINGS

A. Mark Products:
1. Identify the nominal trade size on the product.
2. Stamp with the name or trademark of the manufacturer.

2.7 PULL AND JUNCTION BOXES

A. NEMA 3R Rated:
1. Body and cover: 14 GA minimum, steel finished with rust inhibiting primer and manufacturers standard paint inside and out.
2. Drip shield top and seam-free sides, front and back.
3. With or without concentric knockouts on bottom.
4. Slip-on removable cover fastened on bottom edge with screws or continuous hinged cover fastened with screws.

B. Miscellaneous Accessories:
1. Rigid handles for covers larger than 9 SQFT or heavier than 25 LBS.
2. Split covers when heavier than 25 LBS.
3. Weldnuts for mounting optional panels and terminal kits.
4. Terminal blocks: Screw-post barrier-type, rated 600 volt and 20 ampere minimum.

C. Standards: NEMA 250, UL 50.

2.8 SUPPORT SYSTEMS

A. Multi-conduit Surface or Trapeze Type Support and Pull or Junction Box Supports:
   1. Material requirements.
      a. Galvanized steel: ASTM A123/A123M or ASTM A153/A153M.
      b. Stainless steel: AISI Type 316.
      c. PVC coat galvanized steel: ASTM A123/A123M or ASTM A153/A153M and 20 MIL PVC coating.

B. Single Conduit and Outlet Box Support Fasteners:
   1. Material requirements:
      a. Zinc plated steel.
      b. Stainless steel.
      c. Malleable iron.
      d. PVC coat malleable iron or steel: 20 MIL PVC coating.
      e. Steel protected with zinc phosphate and oil finish.

PART 3 - EXECUTION

3.1 RACEWAY INSTALLATION - GENERAL

A. Shall be in accordance with the requirements of:
   1. NFPA 70.
   2. Manufacturer instructions.

B. Size of Raceways:
   1. Raceway sizes are shown on the Drawings, if not shown on the Drawings, then size in accordance with NFPA 70.
   2. Unless specifically indicated otherwise, the minimum raceway size shall be:
      a. Conduit: 3/4 IN.
      b. Wireway: 2-1/2 IN x 2-1/2 IN.

C. Field Bending and Cutting of Conduits:
   1. Utilize tools and equipment recommended by the manufacturer of the conduit, designed for the purpose and the conduit material to make all field bends and cuts.
   2. Do not reduce the internal diameter of the conduit when making conduit bends.
   3. Prepare tools and equipment to prevent damage to the PVC coating.
   4. Degrease threads after threading and apply a zinc rich paint.
   5. Debur interior and exterior after cutting.

D. Male threads of conduit systems shall be coated with an electrically conductive anti-seize compound.

E. The protective coating integrity of conduits, fittings, outlet, pull and junction boxes and accessories shall be maintained.
   1. Repair galvanized components utilizing a zinc rich paint.
   2. Repair painted components utilizing touch up paint provided by or approved by the manufacturer.
   3. Repair PVC coated components utilizing a patching compound, of the same material as the coating, provided by the manufacturer of the conduit; or a self-adhesive, highly conformable, cross-linked silicone composition strip, followed by a protective coating of vinyl tape.
      a. Total nominal thickness: 40 MIL.
   4. Repair surfaces which will be inaccessible after installation prior to installation.

F. Remove moisture and debris from conduit before wire is pulled into place.
   1. Pull mandrel with diameter nominally 1/4 IN smaller than the interior of the conduit, to remove obstructions.

2. Swab conduit by pulling a clean, tight-fitting rag through the conduit.
3. Tightly plug ends of conduit with tapered wood plugs or plastic inserts until wire is pulled.

G. Only nylon or polyethylene rope shall be used to pull wire and cable in conduit systems.

H. Where portions of a raceway are subject to different temperatures and where condensation is known to be a problem, as in cold storage areas of buildings or where passing from the interior to the exterior of a building, the raceway shall be sealed to prevent circulation of warm air to colder section of the raceway.

3.2 RACEWAY ROUTING

A. Raceways shall be routed in the field unless otherwise indicated.
   1. Conduit and fittings shall be installed, as required, for a complete system that has a neat appearance and is in compliance with all applicable codes.
   2. Run in straight lines parallel to or at right angles to building lines.
   3. Do not route conduits:
      a. Through areas of high ambient temperature or radiant heat.
      b. In suspended concrete slabs.
      c. In concrete members including slabs, slabs on grade, beams, walls, and columns unless specifically located and detailed on structural Drawings..
   4. Locate sleeves or conduits penetrating floors, walls, and beams so as not to significantly impair the strength of the construction. Do not place conduit penetrations in columns.
   5. Conduit shall not interfere with, or prevent access to, piping, valves, ductwork, or other equipment for operation, maintenance and repair.
   6. Provide pull boxes or conduit bodies as needed so that there is a maximum of 360 DEG of bends in the conduit run or in long straight runs to limit pulling tensions.

B. All conduits within a structure shall be installed exposed except as follows:
   1. As indicated on the Drawings.

C. Maintain minimum spacing between parallel conduit and piping runs in accordance with the following when the runs are greater than 30 FT:
   1. Between 600 V and less AC and greater than 600 VAC: 2 IN.

D. Conduits shall be installed to eliminate moisture pockets.
   1. Where water cannot drain to openings, provide drain fittings in the low spots of the conduit run.

E. Conduit shall not be routed on the exterior of structures except as specifically indicated on the Drawings.

F. Where sufficient room exists within the housing of roof-mounted equipment, the conduit shall be stubbed up inside the housing.

G. Provide all required openings in slabs for conduit penetration.
   1. New construction:
      a. Sleeves and blockouts:
         1) Set in concrete slabs during forming.
      b. Sleeves not considered to structurally replace the displaced concrete.

3.3 RACEWAY APPLICATIONS

A. Permitted Raceway Types Per Wire or Cable Types:
   1. Power wire or cables: All raceway types.

B. Permitted Raceway Types Per Area Designations:
   1. Wet areas:
      a. RGS.

C. Permitted Raceway Types Per Routing Locations:
   1. Embedded in poured concrete pads:

a. PVC-40.
b. PVC-RGS when emerging from concrete into areas designated as wet, corrosive or highly corrosive.

2. Direct buried conduits and ductbanks:
   a. PVC-80.
   b. Fiberglass (above or below grade rated).
   c. 90 DEG elbows for transitions to above grade:
      1) PVC-RGS.
      2) Fiberglass (above grade rated).
   d. Long sweeping bends greater than 15 DEG:
      1) PVC-RGS.
      2) Fiberglass (above or below grade rated).
3. Concrete encased ductbanks:
   a. PVC-40.
   b. PVC-EB.
   c. Fiberglass (above or below grade rated).
   d. 90 degree elbows:
      1) PVC-RGS.
      2) Fiberglass (above grade rated).
   e. Long sweeping bends greater than 15 DEG:
      1) RGS for sizes 2 IN and larger.
      2) Fiberglass (above or below grade rated).

D. Underground Conduit: See Specification Section 26 05 43.

3.4 CONDUIT FITTINGS AND ACCESSORIES

A. Conduit Seals:
1. Installed in conduit systems located in hazardous areas as required by the NFPA 70.
2. Fill plug and drain shall be accessible.
3. Pour the conduit seals in a two-step process.
   a. Pour the seal and leave cover off.
   b. After seal is dry, inspect for proper sealing, install cover and mark (for example, paint or permanent marker) as complete.

B. Rigid nonmetallic conduit and fittings shall be joined utilizing solvent cement.
1. Immediately after installation of conduit and fitting, the fitting or conduit shall be rotated 1/4 turn to provide uniform contact.

C. Install Expansion Fittings:
1. Where conduits are exposed to the sun and conduit run is greater than 200 FT.
2. Elsewhere as identified on the Drawings.

D. Install Expansion/Deflection Fittings:
1. Where conduits enter a structure.
   a. Except electrical manholes and handholes.
   b. Except where the ductbank is tied to the structure with rebar.
2. Where conduits span structural expansions joints.
3. Elsewhere as identified on the Drawings.

E. Threaded connections shall be made wrench-tight.

F. Conduit joints shall be watertight:
1. Where subjected to possible submersion.
2. In areas classified as wet.
3. Underground.

G. Terminate Conduits:
1. In metallic outlet boxes:
   a. RGS:

1) Conduit hub and locknut.
2) Insulated bushing and two locknuts.
3) Use grounding type locknut or bushing when required by NFPA 70.

b. EMT: Compression type connector and locknut.

2. In NEMA 3R, NEMA 4 and NEMA 4X rated enclosures:
   a. Watertight, insulated and gasketed hub and locknut.
3. In NEMA 7 and NEMA 9 rated enclosures:
   a. Into an integral threaded hub.
4. When stubbed up through the floor into floor mount equipment:
   a. With an insulated grounding bushing on metallic conduits.
   b. With end bells on nonmetallic conduits.

H. Threadless couplings shall only be used to join new conduit to existing conduit when the existing conduit end is not threaded and it is not practical or possible to cut threads on the existing conduit with a pipe threader.

3.5 CONDUIT SUPPORT

A. Permitted multi-conduit surface or trapeze type support system per area designations and conduit types:
   1. Dry or wet and/or hazardous areas:
      a. Galvanized system consisting of: Galvanized steel channels and fittings, nuts and hardware and conduit clamps.
      b. Aluminum system consisting of: Aluminum channels, fittings and conduit clamps with stainless steel nuts and hardware.
   2. Conduit type shall be compatible with the support system material.
      a. Galvanized steel system may be used with RGS and EMT.
      b. Stainless steel system may be used with RGS and PVC-RGS.
      c. PVC coated galvanized steel system may be used with PVC-RGS and PVC-80.
      d. Fiberglass system may be used with PVC-40 and PVC-80 and PVC-RGS.

B. Permitted single conduit support fasteners per area designations and conduit types:
   1. Architecturally finished areas:
      a. Material: Zinc plated steel, or steel protected with zinc phosphate and oil finish.
      b. Types of fasteners: Spring type hangers and clips, straps, hangers with bolts, clamps with bolts and bolt on beam clamps.
      c. Provide anti-rattle conduit supports when conduits are routed through metal studs.
   2. Dry or wet and/or hazardous areas:
      a. Material: Zinc plated steel, stainless steel and malleable iron.
      b. Types of fasteners: Straps, hangers with bolts, clamps with bolts and bolt on beam clamps.
   3. Corrosive areas:
      a. Material: Stainless steel and PVC coat malleable iron or steel.
      b. Types of fasteners: Straps, hangers with bolts, clamps with bolts and bolt on beam clamps.
   4. Highly corrosive areas:
      a. Material: PVC coat malleable iron or steel.
      b. Types of fasteners: Straps, hangers with bolts, clamps with bolts and bolt on beam clamps.
   5. Conduit type shall be compatible with the support fastener material.
      a. Zinc plated steel, steel protected with zinc phosphate and oil finish and malleable iron fasteners may be used with RGS and EMT.
      b. Stainless steel system may be used with RGS and PVC-RGS and RAC.
      c. PVC coated fasteners may be used with PVC-RGS.
      d. Nonmetallic fasteners may be used with PVC-40, PVC-80 and fiberglass.

C. Conduit Support General Requirements:
   1. Maximum spacing between conduit supports per NFPA 70.

2. Support conduit from the building structure.
3. Do not support conduit from process, gas, air or water piping; or from other conduits.
4. Provide hangers and brackets to limit the maximum uniform load on a single support to 25 LBS or to the maximum uniform load recommended by the manufacturer if the support is rated less than 25 LBS.
    a. Do not exceed maximum concentrated load recommended by the manufacturer on any support.
    b. Conduit hangers:
        1) Continuous threaded rods combined with struts or conduit clamps: Do not use perforated strap hangers and iron bailing wire.
    c. Do not use suspended ceiling support systems to support raceways.
    d. Hangers in metal roof decks:
        1) Utilize fender washers.
        2) Not extend above top of ribs.
        3) Not interfere with vapor barrier, insulation, or roofing.
5. Conduit support system fasteners:
    a. Use sleeve-type expansion anchors as fasteners in masonry wall construction.
    b. Do not use concrete nails and powder-driven fasteners.

3.6 OUTLET, PULL AND JUNCTION BOX INSTALLATION

A. General:
1. Install products in accordance with manufacturer's instructions.
2. See Specification Section 26 05 00 and the Drawings for area classifications.
3. Fill unused punched-out, tapped, or threaded hub openings with insert plugs.
4. Size boxes to accommodate quantity of conductors enclosed and quantity of conduits connected to the box.

B. Pull and Junction Boxes:
1. Install pull or junction boxes in conduit runs where indicated or required to facilitate pulling of wires or making connections.
    a. Make covers of boxes accessible.
2. Permitted uses of NEMA 4 enclosure:
    a. Pull or junction box surface mounted in areas designated as wet.

END OF SECTION

SECTION 26 05 43
ELECTRICAL - EXTERIOR UNDERGROUND

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Material and installation requirements for:
      a. Manholes.
      b. Handhole.
      c. Underground conduits and ductbanks.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Division 03 - Concrete.
   4. Section 03 00 05 - Concrete.
   5. Section 10 14 00 - Identification Devices.
   6. Section 26 05 26 - Grounding.
   7. Section 26 05 33 - Raceways and Boxes.
   8. Section 31 23 33 - Trenching, Backfilling and Compacting for Utilities.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American Association of State Highway and Transportation Officials (AASHTO):
      a. HB-17, Standard Specifications for Highway Bridges.
   2. ASTM International (ASTM):
      a. A536, Standard Specification for Ductile Iron Castings.
   3. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   4. Society of Cable Telecommunications Engineers (SCTE):
      a. 77, Specifications for Underground Enclosure Integrity.

1.3 DEFINITIONS

A. Direct-Buried Conduit(s):
   1. Individual (single) underground conduit.
   2. Multiple underground conduits, arranged in one or more planes, in a common trench.

B. Concrete Encased Ductbank: An individual (single) or multiple conduit(s), arranged in one or more planes, encased in a common concrete envelope.

1.4 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data:
      a. Provide submittal data for all products specified in PART 2 of this Specification Section.
   3. Fabrication and/or layout drawings:
      a. Provide dimensional drawings of each handhole indicating all specified accessories and conduit entry locations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Precast manholes and handholes:
      a. Lister Industries Ltd.
      b. Oldcastle Enclosure Solutions.
      c. Jensen Precast and Utility Concrete Products.
   2. Manhole and handhole and ductbank accessories:
      a. Cantex, Inc.
      b. Condux International, Inc.
      c. Neenah Enterprises, Inc.
      d. Prime Conduit.
      e. Thomas and Betts.
      f. Underground Devices, Inc.
      g. Unistrut by Atkore International, Inc.

2.2 MANHOLES AND HANDHOLES

A. Precast Manholes and Handholes:
   1. Fiberglass reinforced polymer concrete or steel reinforced cement concrete structures:
   2. AASHTO live load rating: H-20 for full deliberate vehicle traffic.
   3. Mating edges: Tongue and groove type.
   4. Solid bottom with a 12 IN x 12 IN or 12 IN DIA french drain in the bottom of each manhole.
   5. Cable pulling eyes opposite all conduit entrances.

B. Precast Vaults:
   1. Fiberglass reinforced polymer concrete or steel reinforced cement concrete structures:
   2. AASHTO live load rating: H-20 for full deliberate vehicle traffic.
   3. Mating edges: Tongue and groove type.
   4. Solid bottom with a 12 IN x 12 IN or 12 IN DIA french drain in the bottom of each vault.
   5. Cable pulling eyes opposite all conduit entrances.
   6. Steel lid.

2.3 CONCRETE MANHOLE AND HANDHOLE ACCESSORIES

A. Cover and Frame:
   1. Cast ductile iron: ASTM A536.
   2. AASHTO live load rating: H-20.
   3. Diameter: 30 IN.
   4. Cast the legend "ELECTRICAL" or "COMMUNICATIONS" into manhole and handhole covers.

B. Cable Racks and Hooks:
   1. Material: Heavy-duty nonmetallic (glass reinforced nylon).
   2. Hook loading capacity: 400 LBS minimum.
   3. Rack loading capacity: Four hooks maximum.
   4. Hook deflection: 0.25 IN maximum.
   5. Hooks: Length, as required, with positive locking device to prevent upward movement.
   6. Mounding hardware: Stainless steel.

C. Cable Pulling Irons:
   1. 7/8 IN DIA hot-dipped galvanized steel.
   2. 6000 LB minimum pulling load.

D. Ground Rods and Grounding Equipment: See Specification Section 26 05 26.

2.4 UNDERGROUND CONDUIT AND ACCESSORIES

A. Concrete and reinforcing steel: See Division 03 Specifications.

B. Conduit: See Specification Section 26 05 33.

C. Duct Spacers/Supports:
   1. High density polyethylene or high impact polystyrene.
   2. Interlocking web or mesh design.
   3. Provide 2 IN minimum spacing between conduits.
   4. Accessories, as required:
      a. Hold down bars.
      b. Ductbank strapping.

PART 3 - EXECUTION

3.1 GENERAL

A. Drawings indicate the intended location of manholes and handholes and routing of ductbanks and direct buried conduit.
   1. Field conditions may affect actual routing.

B. Handhole Locations:
   1. Approximately where shown on the Drawings.
   2. As required for pulling distances.
   3. As required to keep pulling tensions under allowable cable tensions.
   4. As required for number of bends in ductbank routing.
   5. Shall not be installed in a swale or ditch.
   6. Determine the exact locations after careful consideration has been given to the location of other utilities, grading, and paving.
   7. Locations are to be approved by the Engineer prior to excavation and placement or construction of manholes and handholes.

C. Install products in accordance with manufacturer's instructions.

D. Install manholes and handholes in conduit runs where indicated or as required to facilitate pulling of wires or making connections.

E. Comply with Specification Section 31 23 33 for trenching, backfilling and compacting.

3.2 MANHOLES, HANDHOLES AND VAULTS

A. Precast Manholes, Handholes and Vaults:
   1. For use in vehicular and non-vehicular traffic areas.
   2. Construction:
      a. Grout or seal all joints, per manufacturer's instructions.
      b. Support cables on walls by cable racks:
         1) Provide a minimum of two racks, install symmetrically on each wall of manholes, vaults and handholes.
            a) Provide additional cable racks, as required, so that both ends of cable splices will be supported horizontally.
         2) Equip cable racks with adjustable hooks: Quantity of cable hooks as required by the number of conductors to be supported.
      c. In each manhole, vaults and handhole, drive 3/4 IN x 10 FT long copper clad ground rod into the earth with approximately 6 IN exposed above finished floor.
         1) Drill opening in floor for ground rod.
         2) Connect all metallic components to ground rod by means of #8 AWG minimum copper wire and approved grounding clamps.
         3) Utilize a ground bar in the manhole, vaults or handhole if the quantity of ground wires exceeds three.

a) Connect ground bar to ground rod with a #2/0 AWG minimum copper wire.

3. Place manhole, vault or handhole on a foundation of compacted 1/4 to 1/2 IN crushed rock or gravel a minimum of 8 IN thick and 6 IN larger than manholes or handholes footprint on all sides.
4. Install so that the top of cover is 1 IN above finished grade.
   a. Where existing grades are higher than finished grades, install sufficient number of courses of curved segmented concrete block between top of handhole, vault and manhole frame to temporarily elevate manhole cover to existing grade level.
5. After installation is complete, backfill and compact soil around manholes, vault and handholes.
6. Handhole size:
   a. As indicated on the Drawings or as required for the number and size of conduits entering or as indicated on the Drawings.
   b. Minimum floor dimension of 4 FT x 4 FT and minimum depth of 4 FT.

3.3 UNDERGROUND CONDUITS

A. General Installation Requirements:
   1. Ductbank types per location:
      a. Concrete encased ductbank:
         1) Under roads.
         2) Conduits containing medium voltage cables.
         3) Pad mounted transformer secondaries.
         4) Plant process equipment feeders and controls.
   2. Do not place concrete or soil until conduits have been observed by the Engineer.
   3. Ductbanks shall be sloped a minimum of 4 IN per 100 FT or as detailed on the Drawings.
      a. Low points shall be at manholes or handholes.
   4. During construction and after conduit installation is complete, plug the ends of all conduits.
   5. Provide conduit supports and spacers.
      a. Place supports and spacers for rigid nonmetallic conduit on maximum centers as indicated for the following trade sizes:
         1) 1 IN and less: 3 FT.
         2) 1-1/4 to 3 IN: 5 FT.
         3) 3-1/2 to 6 IN: 7 FT.
      b. Place supports and spacers for rigid steel conduit on maximum centers as indicated for the following trade sizes:
         1) 1 IN and less: 10 FT.
         2) 1-1/4 to 2-1/2 IN: 14 FT.
         3) 3 IN and larger: 20 FT.
      c. Securely anchor conduits to supports and spacers to prevent movement during placement of concrete or soil.
   6. Stagger conduit joints at intervals of 6 IN vertically.
   7. Make conduit joints watertight and in accordance with manufacturer's recommendations.
   8. Accomplish underground changes in direction of runs exceeding a total of 15 DEG by long sweep bends having a minimum radius of 10 FT.
      a. Sweep bends may be made up of one or more curved or straight sections or combinations thereof.
   9. Furnish manufactured elbows at end of runs as the conduit transitions to above grade.
      a. Minimum radius of 18 IN for conduits less than 3 IN trade size and 36 IN for conduits 3 IN trade size and larger.
   10. Field cuts requiring tapers shall be made with the proper tools and shall match factory tapers.
   11. After the conduit run has been completed:
      a. Prove joint integrity and test for out-of-round duct by pulling a test mandrel through each conduit.
         1) Test mandrel:

a) Length: Not less than 12 IN.
b) Diameter: Approximately 1/4 IN less than the inside diameter of the conduit.

b. Clean the conduit by pulling a heavy duty wire brush mandrel followed by a rubber duct swab through each conduit.

12. Pneumatic rodding may be used to draw in lead wire.
    a. Install a heavy nylon cord free of kinks and splices in all unused new ducts.
    b. Extend cord 3 FT beyond ends of conduit.
13. Transition from rigid nonmetallic conduit to rigid metallic conduit, per Specification Section 26 05 33, prior to entering a structure or going above ground.
    a. Except rigid nonmetallic conduit may be extended directly to manholes, handholes, pad mounted transformer boxes and other exterior pad mounted electrical equipment where the conduit is concealed within the enclosure.
    b. Terminate rigid PVC conduits with end bells.
    c. Terminate steel conduits with insulated bushings.
14. Place warning tape in trench directly over ductbanks, direct-buried conduit, and direct-buried wire and cable in accordance with Specification Section 10 14 00.
15. Placement of conduits stubbing into handholes and manholes shall be located to allow for proper bending radiuses of the cables.

B. Concrete Encased Ductbank:
1. Ductbank system consists of conduits completely encased in minimum 2 IN of concrete and with separations between different cabling types as required in Specification Section 26 05 33 or as detailed on the Drawings.
2. Install so that top of concrete encased duct, at any point:
    a. Is not less than 24 IN below grade.
    b. Is below pavement sub-grading.
3. Where identified and for a distance 10 FT either side of the area, the concrete shall be reinforced.
    a. The reinforcement shall consist of #4 bars and #4 ties placed 12 IN on center, in accordance with Division 03 Specification Sections or as detailed on the Drawings.
    b. Conduit supports to be staggered to minimize weak vertical shear point.
4. Conduit supports shall provide a uniform minimum clearance of 3 IN between the bottom of the trench and the bottom row of conduit.
5. Conduit separators shall provide a uniform minimum clearance of 3 IN between conduits or as required in Specification Section 26 05 33 for different cabling types.

C. Direct-Buried Conduit(s):
1. Install so that the top of the uppermost conduit, at any point:
    a. Is not less than 36 IN below grade.
    b. Is below pavement sub-grading.
2. Provide a uniform minimum clearance of 3 IN between conduits or as required in Specification Section 26 05 33 for different cabling types.
    a. Maintain the separation of multiple planes of conduits by one of the following methods:
        1) Install multilevel conduits with the use of conduit supports and separators to maintain the required separations, and backfill with flowable fill (100 PSI) per Specification Section 31 23 33 or concrete per Division 03 specifications.
        2) Install the multilevel conduits one level at a time.
            a) Each level is backfilled with the appropriate amount of soil and compaction, per Specification Section 31 23 33, to maintain the required separations.

END OF SECTION

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SECTION 26 08 13
ACCEPTANCE TESTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Basic requirements for acceptance testing.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Section 01 61 03 - Equipment - Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Nationally Recognized Testing Laboratory (NRTL).
   2. Telecommunications Industry Association/Electronic Industries Alliance/American National Standards Institute (TIA/EIA/ANSI):
      a. 455-78-B, Optical Fibres - PART 1-40: Measurement Methods and Test Procedures - Attenuation.

B. Qualifications:
   1. Testing firm qualifications: See Specification Section 01 61 03.
   2. Field personnel:
      a. See Specification Section 01 61 03.
      b. As an alternative, supervising technician may be certified by the equipment manufacturer.
   3. Analysis personnel:
      a. See Specification Section 01 61 03
         As an alternative, supervising technician may be certified by the equipment manufacturer.

C. Phasing Diagram:
   1. Coordinate with Utility Company for phase rotations and Phase A, B and C markings.
      a. Create a phasing diagram showing the coordinated phase rotations with generators and motors through the transformers.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. See Specification Section 01 61 03 for electrical equipment and connection testing plan submittal requirements.

B. Informational Submittals:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Prior to energizing equipment:
      a. Coordinated phasing diagram.
      b. Photocopies of continuity tests.
   3. Within two weeks after hand off meeting:
      a. Single report containing information including:
         1) Summary of Project.
         2) Information from pre-energization testing.

3) See testing and monitoring reporting requirements in Specification Section 01 61 03.

PART 2 - PRODUCTS

2.1 FACTORY QUALITY CONTROL

A. Provide Electrical equipment with all factory tests required by the applicable industry standards or NRTL.

B. Factory testing will not be accepted in lieu of field acceptance testing requirements specified in this Specification Section and Specification Section 01 61 03.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. General:
   1. See Specification Section 01 61 03.
   2. Complete electrical testing in three phases:
      a. Pre-energization testing phase.
      b. Equipment energized with no load.
      c. Equipment energized under load.
   3. Perform testing in accordance with this Specification Section.
   4. Provide field setting and programming of all adjustable protective devices and meters to settings as determined by the approved coordination study.

B. Equipment Monitoring and Testing Plan: See Specification Section 01 61 03.

C. Instruments Used in Equipment and Connections Quality Control Testing: See Specification Section 01 61 03.

D. Testing and Monitoring Program Documentation: See Specification Section 01 61 03.

E. Electrical Equipment and Connections Testing Program:
   1. See Specification Section 01 61 03.
   2. See individual Division 26 Specification Sections for equipment specific testing requirements.
   3. Test all electrical equipment.
      a. Perform all required testing plus the optional testing identified with each specific type of equipment in Article 3.2 of this Specification Section.

3.2 SPECIFIC EQUIPMENT TESTING REQUIREMENTS

A. Switchgear and Switchboards:
   1. Perform inspections and tests per manufacturer's requirements.
   2. Components: Test all components per applicable paragraphs of this Specification Section and NETA ATS.

B. Transformers - Large Dry Type:
   1. Perform inspections and tests per manufacturer's requirements .
   2. Components: Test all components per applicable paragraphs of this Specification Section.
   3. Perform the following additional tests:
      a. Record phase-to-phase, phase-to-neutral, and neutral-to-ground voltages at no load after energizing, and at operating load after start-up.
   4. Adjust tap connections as required to provide secondary voltage within 2-1/2 PCT of nominal under normal load.
   5. Record as-left tap connections.

C. Cable - Low Voltage:

1. Perform inspections and tests per manufacturer's requirements .

D. Vertivco Low Voltage Molded Case Circuit Breakers:
   1. Perform inspections and tests per manufacturer's requirements.
   2. Components:
      a. Test all components per applicable paragraphs of this Specification Section.
      b. Thermal magnetic breakers: Visual and mechanical inspection only.
      c. Solid state trip type: Visual and mechanical inspection and electrical tests.
   3. Record as-left settings.

E. Grounding:
   1. Components: Test all components per applicable paragraphs of this Specification Section.

F. Ground Fault Protection:
   1. Perform inspections and tests per manufacturer's requirements.
   2. Components: Test all components per applicable paragraphs of this Specification Section.
   3. Perform the following additional tests for four-wire systems:
      a. Primary current injection into switchgear bus with test set configured to simulate transformer source and high current jumper used to simulate unbalanced load and ground fault conditions.
      b. Verify no tripping for unbalanced load on each feeder and each main breaker.
      c. Verify no tripping for unbalanced load across tie breaker for dual-source schemes.
      d. Verify tripping for ground fault on load side of feeder each feeder and on each main bus.
      e. Verify tripping for ground fault on a single feeder and on each main bus through tie breaker(s) for multiple-source schemes.

END OF SECTION

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SECTION 26 09 13
ELECTRICAL METERING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Digital metering equipment.

B. Related Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Section 26 05 00 - Electrical - Basic Requirements.
   4. Section 26 08 13 - Acceptance Testing.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   2. National Electrical Manufacturers Association/American National Standards Institute (NEMA/ANSI):
      a. C12.20, For Electricity Meter - 0.2 and 0.5 Accuracy Classes.
   3. Underwriters Laboratories, Inc. (UL):
      a. 508, Standard for Safety Industrial Control Equipment.

B. Metering per Pudget Sound Energy Requirements.
   1. All metering equipment shall be EUSERC equipment.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data including:
      a. Provide submittal data for all products specified in PART 2 of this Specification:
      b. See Section 26 05 00 for additional requirements.
   3. Fabrication and/or layout drawings.
      a. Electrical wiring/connection diagrams.

B. Contract Closeout Information:
   1. Operation and Maintenance Data:
      a. See Specification Section 01 33 04 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.
      b. Content of Operation and Maintenance Manual:
         1) Data sheet of the meters electrical parameters, configuration and characteristics including a complete model number and associated equipment connected too.
         2) Operating instructions of the meter(s) supplied.
         3) Operating instructions of the Power Management software.
         4) Maintenance instructions.
         5) As-constructed electrical wiring/connection diagrams.
         6) Acceptance testing data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Allen-Bradley.
   2. Eaton.
   3. Electro Industries.
   4. General Electric Company.
   5. Power Measurement.
   6. Square D Company.
   7. Siemens.

2.2 DIGITAL METERING DEVICES

A. General:
   1. Direct reading metered or calculated values.
   2. Microprocessor based.
   3. Integral LED or LCD display.
   4. Current and potential transformers as required.
   5. Integral fusing.
   6. Operating temperature: 0 DEGF to 150 DEGF.
   7. Standards:
      a. NEMA/ANSI C12.20.
      b. UL 508.

B. Type 'A' Low Range Meter:
   1. Display the following minimum electrical parameters (accuracy):
      a. RMS current per phase (+0.3 PCT full scale).
      b. RMS voltage line-to-line and line-to-neutral (+0.3 PCT full scale).
   2. Communication ports and protocols: Ethernet TCP/IP.
   3. Supply voltage: 120 VAC.

C. Type 'B' Midrange Meter:
   1. Display the following minimum electrical parameters (accuracy):
      a. RMS current per phase (+0.3 PCT full scale).
      b. RMS voltage line-to-line and line-to-neutral (+0.3 PCT full scale).
      c. Real power (W): 3 PH total (+0.6 PCT full scale).
      d. Apparent power (VA): 3 PH total (+0.6 PCT full scale).
      e. Reactive power (VAR): 3 PH total (+0.6 PCT full scale).
      f. Power factor (+1.0 PCT).
      g. Frequency (+0.17 PCT).
      h. Percent current total harmonic distortion (31st).
      i. Percent voltage total harmonic distortion (31st).
   2. Data logging:
      a. 128 KB.
      b. Selectable for parameters listed above for display.
      c. Software for configuration, retrieval, and trending.
   3. Communication ports and protocols: Ethernet TCP/IP.
   4. Supply voltage: 120 VAC.

D. Type 'C' High Range Meter:
   1. Display the following minimum electrical parameters (accuracy):
      a. RMS current per phase (+0.2 PCT full scale).
      b. RMS voltage line-to-line and line-to-neutral (+0.2 PCT full scale).
      c. Real power (W): 3 PH total (+0.4 PCT full scale).
      d. Apparent power (VA): 3 PH total (+0.4 PCT full scale).
      e. Reactive power (VAR): 3 PH total (+0.4 PCT full scale).

f. Power factor (+1.0 PCT).
g. Frequency (+0.04 PCT).
h. Percent current individual harmonic and total harmonic distortion (50th).
i. Percent voltage individual harmonic and total harmonic distortion (50th).
j. Watt-hours (0.5 PCT).
k. VAR-hours (1.0 PCT).
l. VA-hours (0.5 PCT).
m. Ampere demand (+0.2 PCT full scale).
n. Watt demand (+0.4 PCT full scale).
o. VAR demand (+0.4 PCT full scale).
p. VA demand (+0.4 PCT full scale).

2. Data logging:
   a. 128 KB.
   b. Selectable for parameters listed above for display.
   c. Software for configuration, retrieval, and trending.
3. NEMA/ANSI C12.20, Class 0.2 revenue accuracy.
4. Communication ports and protocols: Ethernet TCP/IP.
5. Supply voltage: 120 VAC.

2.3 ACCESSORIES

A. Operator Interface Personal Computer:
   1. Computer to be industry standard office type with the following minimum features:
      a. Processor: Intel or clone.
      b. USB ports.
      c. Hard drive.
      d. CD/DVD drive.
      e. Keyboard.
      f. Mouse.
      g. 17 IN LCD Monitor:
      h. Operating System: Microsoft Windows.
      i. Compatible with the Power Management and Control Software.

B. Printer:
   1. Color ink jet office type.
   2. Letter size paper.
   3. 250 sheet input tray.
   4. Duplex printing.
   5. Connectivity: USB and Ethernet.

C. Power Management and Control Software:
   1. Manufacturer's standard see Part 3 for minimum functionality.

D. Separately Mounted Enclosure:
   1. NEMA 12 rated for indoor locations.
   2. NEMA 4 rated for outdoor locations.
   3. Hinged front opening door with padlockable latch.
   4. Input/output terminal blocks and wiring.
   5. Separate control voltage source disconnect switch and wiring.
   6. 600 Volt rated power voltage terminal blocks and wiring.
   7. Current transformer shorting terminal blocks and wiring.

2.4 MAINTENANCE MATERIALS

A. One set of replacement printer ink cartridges.

B. One ream (500 sheets) printer paper.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as indicated and in accordance with manufacturer's recommendations and instructions.
   1. Provide all equipment as necessary to provide a complete and functioning system.
   2. Coordinate with the Owner on final computer screen layouts, trending requirements and printouts.

B. Meter Type Application:
   1. Type A meters: Integral to equipment as indicated on the Drawings
   2. Type B meters: Integral to equipment as indicated on the Drawings
   3. Type C meters: Integral to equipment as indicated on the Drawings

C. Communication Configuration:
   1. As indicated on the Drawings.

D. Computer Screen Configuration:
   1. Each Type A, B and C meter shall have a data screen with the following minimum data as applicable for the capabilities of that type of meter:
      a. Voltage line-to-line for each phase and an average.
      b. Voltage line-to-neutral for each phase and an average.
      c. Current for each phase, neutral and average and peak demands.
      d. Kilowatts (kW) for each phase, total, demand and peak demand.
      e. Kilovolt-amperes (kVA) for each phase, total, demand and peak demand.
      f. Kilovolt-amperes reactive (kVAR) for each phase, total, demand and peak demand.
      g. Power factor for each phase and total.
      h. Frequency.
      i. Voltage total harmonic distortion for each phase.
      j. Current total harmonic distortion for each phase.
      k. Energy (kWhr) for each phase and total.
      l. A seven day kW, kVA and kVAR trend average.
      m. Peak demands shall be resettable by the operator.
   2. Meter Typesshall have the following 15 minute trending graphs.
      a. Duration: Adjustable, with a seven day default.
      b. Phase A current: Minimum, maximum and average.
      c. Phase B current: Minimum, maximum and average.
      d. Phase C current: Minimum, maximum and average.
      e. Neutral current: Minimum, maximum and average.
      f. Phase A Watts: Minimum, maximum and average.
      g. Phase B Watts: Minimum, maximum and average.
      h. Phase C Watts: Minimum, maximum and average.
      i. Watts total.
      j. Phase A Voltamps: Minimum, maximum and average.
      k. Phase B Voltamps: Minimum, maximum and average.
      l. Phase C Voltamps: Minimum, maximum and average.
      m. Voltamps total.
      n. Phase A power factor: Minimum, maximum and average.
      o. Phase B power factor: Minimum, maximum and average.
      p. Phase C power factor: Minimum, maximum and average.
      q. Power factor total.

3.2 FIELD QUALITY CONTROL

A. Acceptance Testing: See Section 26 08 13.

3.3 TRAINING

A. A qualified factory-trained manufacturer's representative shall provide the Owner with 8 HRS of on-site training in the operation and maintenance of the metering system and its components.

END OF SECTION

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SECTION 26 23 00
SWITCHGEAR

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Low voltage metal-enclosed switchgear.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Section 26 05 00 - Electrical - Basic Requirements.
   4. Section 26 09 13 - Electrical Metering Devices.
   5. Section 26 28 00 - Overcurrent and Short Circuit Protective Devices.
   6. Section 26 43 13 - Low Voltage Surge Protective Devices (SPD).

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American National Standards Institute (ANSI).
   2. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   3. Underwriters Laboratories, Inc. (UL):
      a. 1558, Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear.

B. Verify the space required for the switchgear is equal to or less than the space allocated.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data:
      a. Provide submittal data for all products specified in PART 2 of this Specification Section.
      b. Nameplate data for all equipment.
      c. Mounting details and equipment weights.
      d. Installation instructions and procedures.
      e. See Specification Section 26 05 00 for additional requirements
   3. Fabrication and/or layout drawings:
      a. General arrangement plan view showing door swings, cable entrance locations, shipping splits, etc.
      b. Cross sections, elevations and details.
      c. Mimic bus layout.
      d. Complete single-line and three-line diagrams.
      e. AC and/or DC schematics of breaker control, metering, etc.
      f. Point-to-point/terminal block wiring diagrams.

B. Contract Closeout Information:
   1. Operation and Maintenance Data:
      a. See Specification Section 01 33 04 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.
   2. Fabrication and/or layout drawings updated with as-built conditions.

C. Informational Submittals:

1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
2. Service equipment marking and documentation.
3. Installation certification report signed by the manufacturer's representative.
4. Ground fault protection system test reports signed by the projects supervising electrical foreman.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Eaton.
   2. General Electric.
   3. Square D by Schneider Electric.
   4. Siemens Corporation.

2.2 SWITCHGEAR

A. Ratings:
   1. Voltage, number of phases, number of wires, and main bus current rating as indicated on the Drawings.
   2. Assembly short circuit current and circuit breaker fault interrupting rating as indicated on the Drawings.
   3. Bus system with a minimum ANSI 4-cycle short circuit withstand rating of 100 KAIC.
   4. Service Entrance Equipment rated when indicated on the Drawings.
   5. 100 PCT rated when 100 PCT rated breakers are installed.

B. Construction:
   1. Standards: IEEE C37.20.1, UL 1558.
   2. Completely enclosed, dead-front, self-supporting metal structure.
   3. Vertical panel sections bolted together.
   4. Each vertical panel section is a self-contained housing with individual breaker or instrument compartments, a centralized bus compartment and a rear cabling compartment.
   5. Individual circuit breaker compartments are segregated from adjacent compartments and sections, including the bus compartment, by means of steel barriers.
   6. Traveling-type overhead circuit breaker lifter, rail-mounted on top of switchgear.
   7. Bus protected by appropriate metal or nonmetallic barriers, shields and shutters.
   8. NEMA 3R rated weatherproof enclosure:
      a. Non-Walk-in type with sloping roof downward toward rear.
      b. Front access type gear housing.
      c. Ventilating openings with replaceable filters.
      d. Heavy-duty door hinges allowing easy access to the breaker internal compartment.
      e. Cassette design allowing breaker maintenance without de-energizing the entire system.
      f. Modular so future sections can be added.
      g. Cable compartment providing ample room for terminating power cables.
   9. Interior and exterior steel surfaces cleaned and painted with rust inhibiting primer and manufacturer's standard paint.

C. Buses:
   1. Material: Tin-plated copper or silver-plated copper.
   2. Main horizontal bus:
      a. Fully rated and continuous over length of switchboard with all three phases arranged in the same vertical plane.
      b. Sufficient size to limit temperature rise to 65 DEGC over average air temperature outside the enclosure of 40 DEGC.
      c. Insulated with a minimum of 5 MIL thickness of epoxy resin coating.

1) Removable non-PVC boots used to give access to the cross bus joints.

3. Neutral bus: Fully rated and continuous over length of switchboard.
4. Ground bus: 1/4 x 2 IN copper, continuous over length of switchboard, solidly grounded to each vertical section structure and meet the short time withstand rating of the largest breaker.
5. Bus joints connected using through bolts and conical spring-type washers for maximum conductivity.

D. Overcurrent and Short Circuit Protective Devices:
   1. Main overcurrent protective device:
      a. Drawout low voltage power circuit breaker.
   2. Feeder overcurrent protective devices:
      a. Drawout low voltage power circuit breaker.
   3. See Specification Section 26 28 00 for overcurrent and short circuit protective device requirements.
   4. Factory installed.
   5. Means to padlock all main and feeder devices in the open position.

E. Surge Protective Device: Integrally mounted, see Specification Section 26 43 13.

F. Metering:
   1. Power monitor:
      a. Separate compartment with hinged door.
      b. See Specification Section 26 09 13 for meter requirements.

G. Accessories:
   1. Coordinate installation methods and provide lay down brackets or other hardware to facilitate the installation of the gear without damage.
   2. Thermograph viewing windows for infrared surveys without opening doors:
      a. Provide windows at manufacturer's recommended locations to view cable connections and bus connections."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install switchgear in accordance with manufacturer's instructions.

B. Arrange switchgear as shown on the Drawings.

C. Outdoor location:
   1. NEMA 3R enclosure.
   2. Install on concrete pad, align front of switchgear with top edge of pad chamfer and securely bolt to floor sills set level and embedded in the concrete.

D. Service Equipment Marking and Documentation:
   1. Provide service rated equipment with available fault current and arc-flash hazard warning labels as required by NFPA 70 and other applicable codes.
   2. Provide documentation of the calculations made for compliance with the marking requirements.
   3. Provide labels in accordance with Section 10 14 00.

E. Miscellaneous:
   1. Provide circuit protective devices and other associated equipment as indicated on the Drawings.
   2. Neatly lace all control wires and have flexibility at hinge locations.

3.2 FIELD QUALITY CONTROL

A. A qualified factory-trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations.

B. Test the ground fault protection system as indicated in Specification Section 26 28 00.

3.3 TRAINING

A. A qualified factory-trained manufacturer's representative shall provide the Owner with 4 HRS of on-site training in the operation and maintenance of the switchgear and its' components.

END OF SECTION

SECTION 26 24 16
PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Distribution panelboards.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Section 10 14 00 – Identification Devices.
   4. Section 26 05 00 - Electrical - Basic Requirements.
   5. Section 26 09 13 – Electrical Metering Devices.
   6. Section 26 28 00 - Overcurrent and Short Circuit Protective Devices.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. PB 1, Panelboards.
   2. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   3. Underwriters Laboratories, Inc. (UL):
      a. 50, Enclosures for Electrical Equipment, Non-Environmental Considerations.
      b. 67, Standard for Panelboards.

1.3 DEFINITIONS

A. Distribution Panelboard: Bus rating of 400A and greater or where labeled as Distribution Panelboard on the Drawings.

1.4 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data.
      a. Provide submittal data for all products specified in PART 2 of this Specification Section.
      b. See Specification Section 26 05 00 for additional requirements.
   3. Fabrication and/or layout drawings:
      a. Panelboard layout with alphanumeric designation, branch circuit breakers size and type, as indicated in the panelboard schedules.

B. Contract Closeout Information:
   1. Operation and Maintenance Data:
      a. See Specification Section 01 33 04 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.
   2. Panelboard schedules with as-built conditions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Eaton.
   2. ABB/GE.
   3. Square D by Schneider Electric.
   4. Siemens Corporation.

2.2 MANUFACTURED UNITS

A. Standards: NEMA PB 1, NFPA 70, UL 50, UL 67.

B. Ratings:
   1. Current, voltage, number of phases, number of wires as indicated on the Drawings.
   2. Short Circuit Current Rating (SCCR) and/or Ampere Interrupting Current (AIC) ratings equal to or greater than the interrupting rating indicated on the Drawings or in the schedule.
      a. Series rating is not acceptable.
      b. When fault current or minimum interrupting rating is not indicated, use rating of upstream equipment or infinite bus calculation of transformer secondary.
   3. Service Entrance Equipment rated when indicated on the Drawings or when shown to be fed from a utility source.

C. Construction:
   1. Interiors factory assembled and designed such that switching and protective devices can be replaced without disturbing adjacent units and without removing the main bus connectors.
   2. Multi-section panelboards: Feed-through or sub-feed lugs.
   3. Main lugs: Solderless type approved for copper and aluminum wire.

D. Bus Bars:
   1. Main bus bars:
      a. Tin plated aluminum or tin plated copper sized to limit temperature rise to a maximum of 65 DEGC above an ambient of 40 DEGC.
      b. Drilled and tapped and arranged for sequence phasing of the branch circuit devices.
   2. Ground bus and isolated ground bus, when indicated on the Drawings: Solderless mechanical type connectors.
   3. Neutral bus bars: Insulated 100 PCT rated or 200 PCT rated, when indicated on the Drawings and with solderless mechanical type connectors.

E. Overcurrent and Short Circuit Protective Devices:
   1. Main overcurrent protective device:
      a. Main Lug Only.
   2. Branch overcurrent protective devices:
      a. Bolt-on molded case circuit breaker.
   3. See Specification Section 26 28 00 for overcurrent and short circuit protective device requirements.
   4. Factory installed.

F. Enclosure:
   1. Boxes: Code gage galvanized steel, furnish without knockouts.
   2. Trim assembly: Code gage steel finished with rust inhibited primer and manufacturers standard paint inside and out.
   3. Branch circuit panelboard:
      a. Trims supplied with hinged door-in-door construction.
         1) Outer door:
            a) Allows access to the interior of the enclosure.
            b) Hinged to the enclosure.

c) Opened by removal of screws or by operating a mechanical latch located behind the inner door.

2) Inner door:
   a) Allows access to breakers (non-live parts).
   b) Hinged to outer door.
   c) Opened by operation of a keyed corrosion resistant chrome-plated combination lock and catch. Locks for all branch circuit panelboards keyed alike.

b. Trims for surface mounted panelboards, same size as box.
c. Trims for flush mounted panelboards, overlap the box by 3/4 IN on all sides.
d. Nominal 20 IN wide and 5-3/4 IN deep with gutter space in accordance with NFPA 70.
e. Clear plastic cover for directory card mounted on the inside of each door.
f. All Enclosures shall be NEMA 3R rated and door gasketed.

4. Distribution panelboard:
   a. Trims cover all live parts with switching device handles accessible.
   b. Minimum 8 IN deep and less than or equal to 12 IN deep with gutter space in accordance with NFPA 70.
   c. Clear plastic cover for directory card mounted front of enclosure.
   d. Where NEMA 3R or NEMA 12 rating is indicated: Doors gasketed and lockable with corrosion resistant chrome-plated combination lock and catch, all locks keyed alike, or provisions for padlocks.
   e. Where NEMA 4X is indicated: Stainless Steel.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as indicated on the Drawings, in accordance with the NFPA 70, and in accordance with manufacturer's instructions.

B. Support panelboard enclosures from modular channels support structure, per Specification Section 26 05 00.

C. Provide NEMA rated enclosure as indicated on the Drawings. Where enclosure type is not indicated, provide enclosure rating suitable for the atmosphere where equipment is installed.

D. Field identification:
   1. Provide all required tagging and markings per the NFPA 70 and Specification Section 10 14 00.

E. Provide each panelboard with a typed directory:
   1. Identify all circuit locations in each panelboard with the load type and location served.
   2. Use Owner-furnished mechanical equipment designation if different than designation indicated on the Drawings.
   3. Use final building room names and numbers as identified by the Owner if different than designation indicated on the Drawings.
   4. Identify spare overcurrent devices.

END OF SECTION

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SECTION 26 28 00
OVERCURRENT AND SHORT CIRCUIT PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Low voltage circuit breakers.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Section 26 05 00 - Electrical - Basic Requirements.
   4. Section 26 08 13 - Acceptance Testing.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. C37.13, Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures.
      b. C37.16, Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors - Preferred Ratings, Related Requirements, and Application Recommendations.
      c. C37.17, Trip Devices for AC and General Purpose DC Low Voltage Power Circuit Breakers.
   2. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   3. Underwriters Laboratories, Inc. (UL):
      a. 489, Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
      b. 1066, Standard for Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data including:
      a. Provide submittal data for all products specified in PART 2 of this Specification Section.
      b. See Specification Section 26 05 00 for additional requirements.

B. Contract Closeout Information:
   1. Operation and Maintenance Data:
      a. See Specification Section 01 33 04 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

C. Informational Submittals:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Reports:
      a. As-left condition of all circuit breakers that have adjustable settings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Circuit breakers:
      a. Eaton.
      b. General Electric Company.
      c. Square D Company.
      d. Siemens.

2.2 CIRCUIT BREAKERS

A. Molded Case Type:
   1. General:
      a. Standards: UL 489.
      b. Unit construction.
      c. Over-center, toggle handle operated.
      d. Quick-make, quick-break, independent of toggle handle operation.
      e. Manual and automatic operation.
      f. All poles open and close simultaneously.
      g. Three position handle: On, off and tripped.
      h. Molded-in ON and OFF markings on breaker cover.
      i. All breakers shall be three-pole.
      j. Current and interrupting ratings as indicated on the Drawings.
   2. Thermal magnetic type:
      a. Inverse time overload and instantaneous short circuit protection by means of a thermal magnetic element.
      b. Frame size 150 amp and below:
         1) Non-interchangeable, non-adjustable thermal magnetic trip units.
      c. Frame sizes 225 to 2000(trip settings less than 200A):
         1) Interchangeable and adjustable instantaneous thermal magnetic trip units.
   3. Solid state trip type:
      a. Inverse time overload, instantaneous short circuit and ground fault protection by means of a solid state trip element, associated current monitors and flux shunt trip mechanism.
      b. Frame size 1600 amp and above:
         1) 100 PCT rated.
         2) Interchangeable current sensor or rating plug.
         3) Adjustable long time pick-up setting.
            a) Adjustable from 50 to 100 PCT of the current sensor or rating plug.
         4) Adjustable long time delay setting.
         5) Adjustable short time pick-up setting.
         6) Adjustable instantaneous pick-up setting.
         7) Adjustable ground fault pick-up setting, when indicated on the Drawings.
         8) Adjustable ground fault delay setting, when indicated on the Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Current and interrupting ratings as indicated on the Drawings.

B. Series rated systems not acceptable.

C. Devices shall be ambient temperature compensated.

D. Circuit Breakers:

1. Molded case circuit breakers shall incorporate the following, unless indicated otherwise on the Drawings:
    a. Frame sizes 400 amp and less with trip setting less than 400A shall be thermal magnetic type.

3.2 FIELD QUALITY CONTROL

A. Coordinated Power System Protection:
1. Prepare a study to demonstrate that the equipment and system constructed within the scope of these Contract Documents, meet the specified requirements for equipment ratings, coordination and protection.
2. Perform the studies in accordance with IEEE 242 and IEEE 399.
3. Include the name of the software developer, software package and software version number in the computer generated studies.
4. System short circuit study report:
    a. Begin the study at the main service electrical gear and extend down the system through all buses.
        1) Perform a balanced three-phase fault, bolted line-to-line fault and line-to-ground fault study.
    b. Prepare a one-line diagram to show the electrical system buses, transformers and all sources of fault current including generators and motors.
    c. Utilize manufacturer's data for the actual proposed equipment (e.g., transformer impedance).
    d. Coordinate the available utility fault current with the power utility company.
    e. Show input data in tabular form in the report and/or on the one-line diagram.
        1) Input data shall include but is not limited to:
            a) Utility fault current or MVA and X/R ratio.
            b) Bus voltages.
            c) Conductor sizes and type of conduit.
            d) Generator and motor sizes and contributions.
            e) Transformer sizes and impedances.
    f. Show available fault current at each bus in tabular form in the report and/or on the one-line diagram.
    g. Perform studies for both normal power and emergency/standby power scenarios.
5. System protective coordination study report:
    a. Begin the study at the main service electrical gear and extend down the system through all buses as required to ensure a coordinated power system.
    b. Demonstrate that the maximum possible degree of selectivity has been obtained between devices specified for the protection of equipment and conductors from damage from overloads and fault conditions.
        1) Where necessary, an appropriate compromise shall be made between system protection and service continuity.
        2) Consider system protection and service continuity to be of equal importance.
    c. Prepare a one-line diagram to show the electrical system buses, transformers and protective devices.
    d. Utilize manufacturer's data for the actual proposed protective devices.
    e. Summarize the coordination study, conclusions and recommendations.
        1) As a minimum, include the following:
            a) The manufacturer's information used to prepare the study.
            b) Assumptions made during the study.
            c) Recommended taps and settings of all adjustable devices in tabulated form.
            d) Composite coordination time-current curves on log-log paper showing:
                (1) That the settings for each protective device will provide protection and selectivity.
                (2) Identify each curve.
                (3) Cable and equipment damage points.

(4) Circuit interrupting device operating and interrupting times.
(5) One-line sketch of the part of the system being investigated.
(6) Include as many curves as possible on a graph while maintaining readability.

e) Position time-current curves for each device to provide for maximum selectivity to minimize system disturbances during fault clearing.

f) Advise the Engineer of potential coordination problems discovered during the study and include recommendations to resolve the problem.
(1) Provide time-current curves for the "as found" and "proposed" conditions for upgrade/retrofit projects.

g) Submit the report for approval 90 days prior to equipment energization.

B. Adjustable Circuit Breakers:
1. Set all circuit breaker adjustable taps as defined on the Drawings, except adjust motor circuit protectors per the motor nameplate and NFPA 70 requirements.

C. Ground Fault Protection System:
1. Single source system:
a. Main breaker using the residual sensing method.

D. Testing:
1. Acceptance testing: See Specification Section 26 08 13.

END OF SECTION

SECTION 26 43 13
LOW VOLTAGE SURGE PROTECTION DEVICES (SPD)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Type 1 SPD - High exposure locations (switchgear, switchboard, panelboard or motor control center), integrally mounted.

B. Related Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. C62.41, Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.
      b. C62.41.1, Guide on the Surge Environment in Low-Voltage (1000V and Less) AC Power Circuits.
      c. C62.41.2, Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits.
      d. C62.45, Recommended Practice on Surge Testing For Equipment Connected to Low-Voltage (1000V and Less) AC Power Circuits.
   2. Military Standard:
      a. MIL-STD-220B, Method of Insertion Loss Measurement.
   3. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   4. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   5. Underwriters Laboratories, Inc. (UL):
      a. 1283, Standard for Electromagnetic Interference Filters.
      b. 1449, Standard for Surge Protective Devices.

B. Qualifications:
   1. Provide devices from a manufacturer who has been regularly engaged in the development, design, testing, listing and manufacturing of SPDs of the types and ratings required for a period of 10 years or more and whose products have been in satisfactory use in similar service.
      a. Upon request, suppliers or manufacturers shall provide a list of not less than three customer references showing satisfactory operation.

1.3 DEFINITIONS

A. Clamping Voltage:
   1. The applied surge shall be induced at the 90 DEG phase angle of the applied system frequency voltage.
   2. The voltage measured at the end of the 6 IN output leads of the SPD and from the zero voltage reference to the peak of the surge.

B. Let-Through Voltage:
   1. The applied surge shall be induced at the 90 DEG phase angle of the applied system frequency voltage.
   2. The voltage measured at the end of the 6 IN output leads of the SPD and from the system peak voltage to the peak of the surge.

C. Maximum Continuous Operating Voltage (MCOV): The maximum steady state voltage at which the SPD device can operate and meet its specification within its rated temperature.

D. Maximum Surge Current:
   1. The maximum 8 x 20 microsecond surge current pulse the SPD device is capable of surviving on a single-impulse basis without suffering either performance degradation or more than 10 PCT deviation of clamping voltage at a specified surge current.
   2. Listed by mode, since number and type of components in any SPD may very by mode.

E. MCC: Motor Control Center.

F. Protection Modes: This parameter identifies the modes for which the SPD has directly connected protection elements, i.e., line-to-neutral (L-N), line-to-line (L-L), line-to-ground (L-G), neutral-to-ground (N-G).

G. Surge Current per Phase:
   1. The per phase rating is the total surge current capacity connected to a given phase conductor.
      a. For example, a wye system surge current per phase would equal L-N plus L-G; a delta system surge current per phase would equal L-L plus L-G.
      b. The N-G mode is not included in the per phase calculation.

H. System Peak Voltage: The electrical equipment supply voltage sine wave peak (i.e., for a 480/277 V system the L-L peak voltage is 679V and the L-N peak voltage is 392 V).

1.4 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data including:
      a. Manufacturer's qualifications.
      b. Standard catalog cut sheet.
      c. Electrical and mechanical drawing showing unit dimensions, weights, mounting provisions, connection details and layout diagram of the unit.
      d. Testing procedures and testing equipment data.
      e. Create a Product Data Sheet for each different model number of SPD provided (i.e., Model XYZ with disconnect and Model XYZ without disconnect, each require a Product Data Sheet).
         1) Data in the Product Data Sheet heading:
            a) SPD Type Number per PART 2 of the Specification.
            b) Manufacturer’s Name.
            c) Product model number.
         2) Data in the Product Data Sheet body:
            a) Column one: Specified value/feature of every paragraph of PART 2 of the Specification.
            b) Column two: Manufacturer’s certified value confirming the product meets the specified value/feature.
            c) Name of the nationally recognized testing laboratory that preformed the tests.
            d) Warranty information.
         3) Data in the Product Data Sheet closing:
            a) Signature of the manufacturer’s official (printed and signed).
            b) Title of the official.
         4) Date of signature.

B. Operation and Maintenance Manuals:
   1. See Specification Section 01 33 04 for requirements for:
      a. The mechanics and administration of submittal process.
      b. The content of the Operation and Maintenance Manuals.

2. Warranty.

1.5 WARRANTY

A. Minimum of a five year Warranty from date of shipment against failure when installed in compliance with applicable national/local electrical codes and the manufacturer's installation, operation and maintenance instructions.

PART 2 - PRODUCTS

2.1 MANUFACTURER CURRENT TECHNOLOGY GENERAL

A. Standards: IEEE C62.41.1, IEEE C62.41.2, IEEE C62.45, MIL-STD 220B, UL 1283, UL 1449.

2.2 TYPE 1 SPD

A. Manufacturers
   1. Eaton – Clipper
   2. Current Technology
   3. Approved Equal

B. Product:
   1. SPD tag number or electrical equipment tag number SPD is connected per manufacturers instructions.
   2. Integrally mounted in switchgear, switchboards or MCCs.
   3. Hybrid solid-state high performance suppression system.
      a. Do not use a suppression system with gas tubes, spark gaps or other components which might short or crowbar the line resulting in interruption of normal power flow to connected loads.
   4. Do not connect multiple SPD modules in series to achieve the specified performance.
   5. Designed for parallel connection.
   6. Field connection: Use mechanical or compression lugs for each phase, neutral and ground that will accept bus bar or #10 through #1/0 conductors.
   7. Device monitor:
      a. Long-life, solid state, externally visible indicators and Form C dry contact(s) that monitors the on-line status of each mode of the units suppression filter system and power loss in any of the phases.
      b. A fuse status only monitor system is not acceptable.

C. Operating Voltage: The nominal unit operating voltage and configuration as indicated on Drawings.

D. Modes of Protection: All modes.
   1. Three phase (delta): L-L, L-G.
   2. Three phase (wye): L-N, L-L, L-G and N-G.
   3. Single phase (2-pole): L-L, L-N, L-G and N-G.
   4. Single phase: L-N, L-G and N-G.

E. Maximum Continuous Operating Voltage: Less than 130 PCT of system peak voltage.

F. Operating Frequency: 45 to 65 Hz.

G. Short Circuit Rating: Equal to or greater than rating of equipment SPD is connected to.

H. Maximum Surge Current: 240,000 A per phase, 120,000 A per mode minimum.

I. Minimum Repetitive Surge Current Capacity: 4000 IEEE C High waveform impulses with no degradation greater than 10 PCT deviation of the clamping voltage.

J. SPD Protection:
   1. Integral unit level and/or component level overcurrent fuses and sustained overvoltage thermal cutout device.

2. An IEEE C High waveforms shall not cause the fuse to open and render the SPD inoperable.

K. Maximum Clamping Voltages: Dynamic test at the 90 degree phase angle including 6 IN lead length and measured from the zero voltage reference:

System Voltage	Test Mode	IEEE C62.41		UL 1449
		C High V & I Wave	B Combination Wave	
L-L < 250 V **L-N < 150 V**	L-L	1470 V	1000 V	800 V
	L-N	850 V	600 V	500 V
	L-G	1150 V	800 V	600 V
	N-G	1150 V	800 V	600 V
L-L > 250 V **L-N > 150 V**	L-L	2700 V	2000 V	1800 V
	L-N	1500 V	1150 V	1000 V
	L-G	2000 V	1550 V	1200 V
	N-G	2000 V	1550 V	1200 V

L. EMI-RFI Noise Rejection: Attenuation greater than 30 dB for frequencies between 100 kHz and 100 MHz.

2.3 SOURCE QUALITY CONTROL

A. SPD approvals and ratings shall be obtained by manufacturers from nationally recognized testing laboratories.

B. The SPD are to be tested as a complete SPD system including:
1. Integral unit level and/or component level fusing.
2. Neutral and ground shall not be bonded during testing.
3. 6 IN lead lengths.
4. Integral disconnect switch when provided.

C. The “as installed” SPD system including the manufacturers recommended circuit breaker, the SPD is connected to, will not open when tested with a IEEE C3 combination waveform.

D. Tests to be performed in accordance with IEEE C62.45:
1. Clamping voltage performance testing using IEEE C62.41 Category waveforms.
2. Single pulse surge current capacity test.
3. Repetitive surge current capacity testing.
4. Spectrum analysis for EMI-RFI noise rejection.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Type 1 SPD:
1. Connected in parallel to the equipment.
2. Install in dedicated electrical equipment compartment, bucket or panelboard box at the factory before shipment.
3. Provide leads that are as short and straight as possible.
4. Maximum lead length: 12 IN.
5. Minimum lead size: #2 stranded AWG or bus bar.
6. Connect leads to the equipment to be protected by one of the following means:

a. Through a circuit breaker or molded case switch mounted in the equipment.
b. Use manufacturer recommended circuit breaker size.
c. Circuit breaker or switch to be operable from the equipment exterior or from behind a hinged door.

END OF SECTION

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DIVISION 31

EARTHWORK

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SECTION 31 23 33

TRENCHING, BACKFILLING, AND COMPACTING FOR UTILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Excavation, trenching, backfilling and compacting for all underground utilities.

B. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Procurement and Contracting Requirements.
   2. Division 01 - General Requirements.
   3. Section 03 31 31 - Concrete Mixing, Placing, Jointing, and Curing.
   4. Division 26 - Electrical.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. ASTM International (ASTM):
      a. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 FT-LBF/FT^3 (600 kN-M/M^3)).
      b. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
      c. D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.

B. Qualifications: Hire an independent soils laboratory to conduct in-place moisture-density tests for backfilling to assure that all work complies with this Specification Section.

1.3 DEFINITIONS

A. Excavation: All excavation will be defined as unclassified.

1.4 SUBMITTALS

A. Shop Drawings:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data including:
      a. Acknowledgement that products submitted meet requirements of standards referenced.
      b. Manufacturer's installation instructions.
   3. Submit respective pipe or conduit manufacturer's data regarding bedding methods of installation and general recommendations.
   4. Submit sieve analysis reports on all granular materials.

B. Informational Submittals:
   1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. Trench shield (trench box) certification if employed:
      a. Specific to Project conditions.
      b. Re-certified if members become distressed.
      c. Certification by registered professional structural engineer, registered in the state where the Project is located.
      d. Engineer is not responsible to, and will not, review and approve.

1.5 SITE CONDITIONS

A. Avoid overloading or surcharge a sufficient distance back from edge of excavation to prevent slides or caving.
   1. Maintain and trim excavated materials in such manner to be as little inconvenience as possible to public and adjoining property owners.

B. Provide full access to public and private premises and fire hydrants, at street crossings, sidewalks and other points as designated by Owner to prevent serious interruption of travel.

C. Protect and maintain bench marks, monuments or other established points and reference points and if disturbed or destroyed, replace items to full satisfaction of Owner and controlling agency.

D. Verify location of existing underground utilities

PART 2 - PRODUCTS

2.1 MATERIALS

A. Backfill Material:
   1. As approved by Engineer.
      a. Free of rock cobbles, roots, sod or other organic matter, and frozen material.
      b. Moisture content at time of placement: ±3 PCT of optimum moisture content as specified in accordance with ASTM D698.
   2. Gravel trench backfill materials:
      a. Uniformly graded pea gravel.

B. Bedding Materials:
   1. Granular bedding materials:
      a. ASTM D2321 Class 1B.
         1) Well-graded crushed stone.

PART 3 - EXECUTION

3.1 GENERAL

A. Remove and dispose of unsuitable materials as directed by Engineer to site provided by Contractor.

3.2 EXCAVATION

A. Unclassified Excavation: Remove rock excavation, clay, silt, gravel, hard pan, loose shale, and loose stone as directed by Engineer.

B. Excavation for Appurtenances:
   1. 12 IN (minimum) clear distance between outer surface and embankment.

C. Groundwater Dewatering:
   1. Where groundwater is, or is expected to be, encountered during excavation, install a dewatering system to prevent softening and disturbance of subgrade to allow pipe, bedding and backfill material to be placed in the dry, and to maintain a stable trench wall or side slope.
   2. Groundwater shall be drawn down and maintained at least 3 FT below the bottom of any trench or manhole excavation prior to excavation.
   3. Review soils investigation before beginning excavation and determine where groundwater is likely to be encountered during excavation.
      a. Employ dewatering specialist for selecting and operating dewatering system.

4. Keep dewatering system in operation until dead load of pipe, structure and backfill exceeds possible buoyant uplift force on pipe or structure.
5. Dispose of groundwater to an area which will not interfere with construction operations or damage existing construction.
6. Install groundwater monitoring wells as necessary.
7. Shut off dewatering system at such a rate to prevent a quick upsurge of water that might weaken the subgrade.
8. Cost of groundwater dewatering shall be included in the bid.

D. Trench Excavation:
1. Excavate trenches by open saw cut method to depth shown on Drawings and necessary to accommodate work.
   a. Support existing utility lines where proposed work crosses at a lower elevation.
      1) Stabilize excavation to prevent undermining of existing utility .
2. Open trench outside buildings, units, and structures:
   a. No more than the distance between two manholes, structures, units, or 500 LF, whichever is less.
   b. Field adjust limitations as weather conditions dictate.
3. Any trench or portion of trench, which is opened and remains idle for seven calendar days, or longer, as determined by the Owner, may be directed to be immediately refilled, without completion of work, at no additional cost to Owner.
   a. Said trench may not be reopened until Owner is satisfied that work associated with trench will be prosecuted with dispatch.
4. Observe following trenching criteria:
   a. Trench size:
      1) Excavate width to accommodate free working space.
      2) Maximum trench width at top of pipe or conduit may not exceed outside diameter of utility service by more than the following dimensions:

OVERALL DIAMETER OF UTILITY SERVICE	EXCESS DIMENSION
33 IN and less	18 IN
more than 33 IN	24 IN

      3) Cut trench walls vertically from bottom of trench to 1 FT above top of pipe, conduit, concrete encasement, or utility service.
      4) Keep trenches free of surface water runoff.
         a) Include cost in Bid.
         b) No separate payment for surface water runoff pumping will be made.

E. Trenching for Electrical Installations:
1. Observe the preceding Trench Excavation paragraph in PART 3 of this Specification Section.
2. Modify for electrical installations as follows:
   a. Open no more than 600 LF of trench in exterior locations for trenches more than 12 IN but not more than 30 IN wide.
   b. Any length of trench may be opened in exterior locations for trenches which are 12 IN wide or less.
   c. Do not over excavate trench.
   d. Cut trenches for electrical runs with minimum 30 IN cover, unless otherwise specified or shown on Drawings.
   e. See Division 26 for additional requirements.

F. Flowable Fill:
1. Flowable fill shall be:

a. Discharged from a mixer by any means acceptable to the Engineer into the area to be filled.
b. Placed in 4 FT maximum lifts to the elevations indicated.
1) Allow 12 HR set-up time before placing next lift or as approved by the Engineer.
2) Place flowable fill lifts in such a manner as to prevent flotation of the pipe.

2. Flowable fill shall not be placed on frozen ground.
3. Subgrade on which flowable fill is placed shall be free of disturbed or softened material and water.
4. Flowable fill batching, mixing, and placing may be started if weather conditions are favorable, and the air temperature is 34 DEGF and rising.
5. At the time of placement, flowable fill must have a temperature of at least 40 DEGF.
6. Mixing and placing shall stop when the air temperature is 38 DEGF or less and falling.
7. Each filling stage shall be as continuous an operation as is practicable.
8. Prevent traffic contact with flowable fill for at least 24 HRS after placement or until flowable fill is hard enough to prevent rutting by construction equipment.
9. Flowable fill shall not be placed until water has been controlled or groundwater level has been lowered in conformance with the requirements of the preceding Groundwater Dewatering paragraph in PART 3 of this Specification Section.

3.3 PREPARATION OF FOUNDATION FOR PIPE LAYING

A. Over-Excavation:
1. Backfill and compact to 90 PCT of maximum dry density per ASTM D698.
2. Backfill with granular bedding material as option.

B. Rock Excavation:
1. Excavate minimum of 6 IN below bottom exterior surface of the pipe or conduit.
2. Backfill to grade with suitable earth or granular material.
3. Form bell holes in trench bottom.

C. Subgrade Stabilization:
1. Stabilize the subgrade when directed by the Owner.
2. Observe the following requirements when unstable trench bottom materials are encountered.
a. Notify Owner when unstable materials are encountered.
1) Define by drawing station locations and limits.
b. Remove unstable trench bottom caused by Contractor failure to dewater, rainfall, or Contractor operations.
1) Replace with subgrade stabilization with no additional compensation.

3.4 BACKFILLING METHODS

A. Do not backfill until tests to be performed on system show system is in full compliance with specified requirements.

B. Carefully Compacted Backfill:
1. Furnish where indicated on Drawings, specified for trench embedment conditions and for compacted backfill conditions up to 12 IN above top of pipe or conduit.
2. Comply with the following:
a. Place backfill in lifts not exceeding 8 IN (loose thickness).
b. Hand place, shovel slice, and pneumatically tamp all carefully compacted backfill.
c. Observe specific manufacturer's recommendations regarding backfilling and compaction.
d. Compact each lift to specified requirements.

C. Common Trench Backfill:
1. Perform in accordance with the following:
a. Place backfill in lift thicknesses capable of being compacted to densities specified.
b. Observe specific manufacturer's recommendations regarding backfilling and compaction.

c. Avoid displacing joints and appurtenances or causing any horizontal or vertical misalignment, separation, or distortion.

D. Water flushing for consolidation is not permitted.

E. Backfilling for Electrical Installations:
1. Observe the preceding Carefully Compacted Backfill paragraph or Common Trench Backfill paragraph in PART 3 of this Specification Section or when approved by the Engineer.
2. Modify for electrical installation as follows:
a. Observe notes and details on electrical drawings for fill in immediate vicinity of direct burial cables.

3.5 COMPACTION

A. General:
1. Place and assure bedding, backfill, and fill materials achieve an equal or higher degree of compaction than undisturbed materials adjacent to the work.
2. In no case shall degree of compaction below minimum compactions specified be accepted.

B. Compaction Requirements:
1. Unless noted otherwise on Drawings or more stringently by other Specification Sections, comply with following minimum trench compaction criteria.
a. Bedding material:

LOCATION	SOIL TYPE	COMPACTION DENSITY
All locations	Cohesionless soils	75 PCT relative density by ASTM D4253 and ASTM D4254

b. Carefully compacted backfill:

LOCATION	SOIL TYPE	COMPACTION DENSITY
All applicable areas	Cohesive soils	95 PCT of maximum dry density by ASTM D698
	Cohesionless soils	75 PCT relative density by ASTM D4253 and ASTM D4254

c. Toe drain bedding and backfill:

LOCATION	SOIL TYPE	COMPACTION DENSITY
All locations	Cohesionless soils	60 PCT relative density by ASTM D4253 and ASTM D4254

d. Common trench backfill:

LOCATION	SOIL TYPE	COMPACTION DENSITY
Under pavements, roadways, surfaces within highway right-of-ways	Cohesive soils	95 PCT of maximum dry density by ASTM D698
	Cohesionless soils	60 PCT of relative density by ASTM D4253 and ASTM D4254
Under turfed, sodded, plant seeded, nontraffic areas	Cohesive soils	85 PCT of maximum dry density by ATM D698
	Cohesionless soils	40 PCT of relative density by ASTM D4253 and ASTM D4254

3.6 FIELD QUALITY CONTROL

A. Testing:
   1. Perform in-place moisture-density tests as directed by the Owner.
   2. Perform tests through recognized testing laboratory approved by Owner.
   3. Costs of "Passing" tests paid by Owner.
   4. Perform additional tests as directed until compaction meets or exceeds requirements.
   5. Cost associated with "Failing" tests shall be paid by Contractor.
   6. Reference to Engineer in this Specification Section will imply Geotechnical Engineer when employed by Owner and directed by Engineer to undertake necessary inspections as approvals as necessary.
   7. Assure Owner has immediate access for testing of all soils related work.
   8. Ensure excavations are safe for testing personnel.

END OF SECTION

DIVISION 33

UTILITIES

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SECTION 33 05 07
HORIZONTAL DIRECTIONAL DRILL

PART 1 - GENERAL REQUIREMENTS

1.1 SUMMARY

A. Contactor to coordinate private utility locate location with the Owner. Owner to provide Subsurface Utility Engineering (SUE), Quality Level B survey based on determined location.

B. Following Owner provided Level B SUE, Contractor shall provide necessary Quality Level A survey for completion and submittal of drilling plan.

C. Contactor shall positively confirm, locate and mark existing lines, cables or other underground facilities, including exposing any facilities located within 10 feet of the designed drill path prior to commencing drilling operations. Modify drilling practices and down-hole assemblies to prevent damage to existing facilities, if necessary. Contractor shall be responsible for losses and repairs occasioned by damage to any above ground or underground facilities resulting from drilling operations.

D. Contractor shall provide the electrical conduit for the project. Submit shop drawing to Owner for evaluation and approval by PSE prior to installation.

E. Contractor shall furnish all supervision, labor, professional and technical services, equipment, materials, surveying, transportation, and supplies to perform the work necessary to install pipe by horizontal directional drilling (HDD) in accordance with the Contract Documents and this specification.

F. For the purposes of this specification, Contractor shall include all subcontractors, suppliers, vendors, or other parties required to complete work defined in the Contract Documents and described in this specification.

G. Contractor shall not proceed with work until the Engineer approves its supervisor, personnel, subcontractors, vendors, Drilling Plan, and schedule. Provide all required documentation, as requested herein, at the specified time identified in the Contract Documents.

H. Contractor will not mobilize to site and/or execute any on-site construction activities without Owner's approval and only after SUE survey is completed and routing has been determined with Owner and PSE.

I. The Owner has or will secure temporary construction easements for workspace and access for drilling sites, as shown on the drawings. Work activities shall remain within the provided easements unless otherwise approved by the Owner and the property owners. All work associated with the preparation of the drilling sites (entry/exit points) and carrier pipe (conduit) stringing/pullback area, will be at Contractor's expense, unless otherwise stated in the Contract Documents.

J. All work shall be contained inside the established limits of construction. In the event additional space is required for staging, stockpiles, storage or any other purpose, the contractor is responsible to secure site access through a construction easement or agreement with property owners. Documentation of property owner approval shall be submitted to the engineer.

K. Contractor shall be responsible for constructing, maintaining, clean up, and restoration for all means of temporary access to the designated work sites and shall include all costs in the bid price and shall be liable for all damages to property within the designated workspaces and easements.

L. Comply with all requirements of permits obtained by the Owner for construction of the pipeline and drilling operations.

M. Contractor shall be responsible for all work necessary for testing, withdrawing, and conveying water to the job site, and shall be responsible for all costs associated with the water usage during drilling operations. Report total water consumption to Owner, as defined in Section 3.6 below.

N. Contractor is responsible for maintaining a clean and sanitary work site. Transport all waste off-site to an Owner-approved disposal site. Provide the preferred disposal site(s) for Owner's review and approval.

O. Provide and maintain all necessary sanitation facilities (portable toilets, garbage cans, dumpsters, etc.).

P. Adhere to the approved Traffic Control Plans established for the Project.

Q. Monitor facilities and other sensitive areas within 500 feet of the drill path or as specified by the Engineer for drilling fluid migration and release. Perform inspection at least three times per shift or more often if any fluid migration is detected and/or slowed or loss of circulation is observed. Engineer may designate certain facilities/features/areas for full-time monitoring by Contractor during drilling operations. Contractor shall be responsible for all costs of personnel and equipment required for monitoring.

R. Drilling practices and downhole assemblies shall be modified to prevent damage to underground facilities.

S. Contractor shall place one call/811 notifications and abide by state regulations before drilling commences.

T. Verify civil survey, confirming workspace and temporary workspace boundaries and pertinent survey points and elevations (entry, exit, abrupt changes along the alignment, obstacles being crossed, etc.) at the crossing location.

U. Review and evaluate the subsurface conditions at the crossing location(s) provided in the Contract Documents and by the Owner in preparation for development of execution plans and risk assessments. If, in the opinion of the Contractor, the information in the Contract Documents is insufficient to execute the scope of work, additional subsurface investigations or engineering assessments can be performed by Contractor at no charge to the Owner.

V. Minimize construction delays when possible without compromising safety or other project requirements in doing so. Sufficient spare parts for HDD equipment and equipment/tooling necessary for implementing mitigation measures shall be readily available such that equipment failure does not extend construction delays.

1.2 RELATED SECTIONS

A. Related Sections include but are not necessarily limited to:
   1. Division 01 – General Requirements
   2. Division 03 – Concrete
   3. Division 31 – Earthwork

1.3 SUBMITTALS

A. List of Key Personnel and Subcontractors per Part 3.2.B.

B. Drilling Schedule per Part 3.2.C.

C. Drilling Plan that includes individual plans as listed in Part 3.2.E.

D. Daily drilling status reports per Part 3.2.F.

E. Pilot hole survey report per Part 3.8.E.

F. Testing, inspections, and acceptance per Part 3.11.

G. Final Project Report 3.11.D.

PART 2 - NOT USED

PART 3 - EXECUTION

3.1 MOBILIZATION

A. Do not mobilize equipment to the job site until Owner grants approval.

B. All HDD equipment and support equipment shall be in good working condition, in compliance with all laws and regulations, and of suitable capacity to perform the anticipated work. Owner or Engineer may inspect all proposed HDD equipment and support equipment for suitability to perform anticipated work. Engineer may require additional or alternative equipment if any inspection identifies that the Contractor's equipment is inadequate to perform the relevant work.

C. All equipment used throughout construction shall have, and display, valid certificates to comply with the applicable laws and regulations of the regulating agencies. Make copies of such certificates available to Engineer upon request.

D. Install secondary spill containment beneath the HDD rig(s) and power unit(s) so any oil or hydrocarbon leaks can be contained and cleaned.

3.2 DRILLING OPERATIONS

A. Access to Equipment Instruments and Support to Owner's representatives and Engineer:
   1. Authorized Representatives and Engineer shall have access inside the drill cab and to all instruments and their readings at all times.

B. Contractor's Key Personnel and Subcontractors
   1. Provide resumes of key personnel and a list of subcontractors that will be on the project. Provide any update(s) to the list should it change either prior to or during construction.
   2. Provide adequate personnel to supervise all aspects of the directional drilling process. Owner or Engineer has the right to reject any supervisory personnel changes during construction. Submit 72-hour advance notification of any proposed supervisory personnel changes during construction to Engineer for approval.
   3. CONTRACTOR is fully responsible for providing the means and methods for all crew changes throughout construction.

C. Drilling Schedule
   1. Submit a drilling schedule. The schedule shall be job specific and comply with the project schedule specified in the Contract Documents. Update the schedule weekly during drilling operations, and resubmit to the Engineer every week during the drilling operations period. The schedule shall address continuity of supervision, quality management, and communication between shifts to address completion of tasks and processes begun in previous shifts or undertaken in subsequent shifts.
   2. At a minimum, the following shall be included in the schedule:
      a. Dates drilling equipment will be prepared for mobilization to site;
      b. Dates for mobilization on site, pilot hole start up, subsequent reaming passes, pullback completion, de-mobilization;
      c. Dates for fabrication (identify if completed prior to commencing drilling) and hydrostatic pre-testing of pullback pipe;
      d. Site preparations (including any casing installations);
      e. Mobilization and rig-up/set-up durations;
      f. Pilot hole drill duration;
      g. Reaming steps with size and duration for each ream pass;
      h. Final hole (swab pass) preparation and pullback duration;
      i. Dates for final inspection;
      j. Clean up, restoration, and de-mobilization duration;
      k. Any other site specific activities required for the particular crossing(s);

l. Daily work schedule for all phases of the project (i.e. 12- or 24-hour work days and number of shifts); and
m. Personnel (supervisor and work crews) schedule for the various work shifts and phases.

3. Submit a 72-hour advance notification prior to any proposed changes in schedule or shutdowns (including holidays) to Engineer for approval. The schedule change or shutdown will not occur without Engineer's approval.

D. Noise Mitigation
1. Supply and install noise mitigation mechanisms to meet any and/or all requirements of applicable permits for the Project, if any.
2. Ensure the equipment used throughout construction meets noise level requirements of the applicable permits, if any.

E. Drilling Plan
1. Submit a Drilling Plan within 15 days after completing SUE QL A. Submit any proposed changes to the Drilling Plan after submittal of the initial Drilling Plan. Prior to beginning any work the Drilling Plan must be approved by Owner.
2. Approval of the Drilling Plan by Engineer does not relieve Contractor of any responsibility or liability for safety, damages, compliance with permits and regulations, accuracy, or adequacy of the plan for execution of the project. Any operational deviation from the submitted plan, including, but not limited to, change in downhole tooling types/sizes, construction methods, etc. shall be submitted to the Engineer. Engineer shall review and approve any deviations to the Drilling Plan prior to implementation by the Contractor.
3. The Drilling Plan shall be site specific and updated during drilling operations. The Drilling Plan shall not override or change requirements of the Contract Documents without written approval from Engineer. The individual plans to be included in the Drilling Plan are listed below. If requested by Engineer, provide supporting data, calculations, and/or other information for each item:
   a. Workspace Layout Plan identifying:
      1) Workspace required to perform the work, if proposing additional to what has been identified in the Contract Documents;
      2) Anticipated layout of all equipment;
      3) Description of secondary containment measures for the drill rig;
      4) Rig anchoring plan and drawings: The drill rig anchoring system shall be sufficient to anchor the rig such that the reported or intended rig capacities can be achieved. When the anchoring system is not part of and/or attached to the drilling rig for demobilization, Contractor shall completely remove it from the site upon completion of drilling.
   b. Equipment Plan identifying:
      1) The size and type of the drilling rig(s), including torque and pulling capacities, and ancillary equipment required for both sides of the HDD crossing;
      2) Size, type, quantities, and purpose of all support equipment and structures that will be used to execute the work;
      3) Drill pipe specifications (grade, size, last inspection date, inspection reports, etc.). Drill pipe, crossover subs, bits, reamers, mud motors, Monel collars, Hevi-Wate, swivels, hole openers and any down-hole tools shall be of suitable size and grade for the work to be performed and be free of defect or damage that may result in a failure. For any tools proposed for the project that may have had prior use and are associated with specified life cycles (i.e. hole openers with roller cones, roller cone bits, etc.), the previously used number of hours and condition(s) for which it/they were used shall be identified to Engineer for review and approval prior to use. Confirm that the equipment is designed in accordance with API RP7G – Recommended Practice for Drill Stem Design and Operating Limits, and inspected in accordance with API RP7G-2 – Recommended Practice for Inspection and Classification of Used Drill Stem Elements or Standard DS-1 Inspection Category 1, 2, 3, 4, or 5. All tool inspections must be coordinated to allow for Engineer to

witness/observe each of the processes, if requested by Engineer. Provide inspection reports to the Engineer prior to the start of construction.

4) Equipment (pumps, etc.) required to obtain water from the Owner's sources.
5) On-site equipment required to continuously monitor sensitive natural areas (as determined by Engineer) during drilling operations;
6) Storage for pipe, drilling fluid, fresh water, and all other consumables and equipment; and
7) Spare equipment and parts inventory.

c. Plan for drilling fluid system (refer to Part 3.3);
d. Plan for drilling fluid composition (refer to Part 3.4);
e. Plan for disposal of drilling fluids and cuttings (refer to Part 3.5);
f. Contingency plan for inadvertent drilling fluid migration and release (refer to Part 3.6);
g. Noise mitigation plan (if required by a Project permit);
h. Casing plan, including size and type, length, installation, removal, and grouting plans (refer to Part 3.7, if required);
i. Pilot Hole execution plan (refer to Part 3.8);
j. Reaming execution plan (refer to Part 3.9);
k. Pullback plan with contingency plan for pullback assistance (refer to Part 3.10);
l. Testing, inspections, and acceptance (refer to Part 3.11);
m. Daily Drilling Status Report (refer to Part 3.2.F);
n. Sample Drilling Fluid Reports (refer to Part 3.4.D);
o. Drilling fluid and cuttings disposal reports (refer to Part 3.5.C).

F. Reporting of Drilling Status

1. Submit daily reports to Engineer at end of each work shift. The reports shall include the following information, as applicable to the relevant phases of construction:
   a. Supervisor on site, crew members on site, shifts and time worked;
   b. Description of work, phase of operation, downhole tools in use, and footage completed;
   c. Pilot hole deviations and corrections made;
   d. Maximum and average annular pressure for each joint completed during pilot hole. If required, and as determined necessary by the Engineer, annular pressure for each reamed joint shall be recorded and reported as well;
   e. Maximum torque values on each pilot or reaming joint;
   f. Maximum push/pull force for each pilot or reaming joint;
   g. Penetration rates for each pilot or reaming joint;
   h. Downhole drilling fluid discharge rates, pressures, and pump times for each pilot or reaming joint;
   i. Copy of directional survey report and report from secondary pilot tracking system(s);
   j. Provide X, Y, Z location data from the secondary tracking and directional survey for each joint as compared to the design drill path;
   k. Provide data to calculate minimum vertical, horizontal, and combination radius of each three joint segment of pilot hole;
   l. Provide an "as-built" drawing (e.g. – AutoCAD and printed to PDF) to represent pilot hole progress to date, any abandoned holes, tools, strings of drill pipe, etc., overlaid on the approved Plan and Profile Design drawing.
   m. Water acquisition volumes and daily consumption from each permitted source;
   n. Daily total of Bentonite used and total to date;
   o. Drilling fluid additives in use, including quantities of each;
   p. Loss of drilling fluid circulation and duration;
   q. Quantity of drilling fluid lost or released and disposition of the fluid released in regard to clean-up;
   r. Disposal quantities of drilling fluid and cuttings;
   s. Disposal bill of lading/trip ticket and lab sample results;
   t. Drilling schedule updates;
   u. Drilling Plan updates;
   v. Drilling fluid system (i.e. product/additive changes, etc.) updates;

w. Drilling fluid properties report;
x. List of any submitted and/or approved changes to the Drilling Plan during that shift.

2. Engineer may require the use of an Electronic Data Acquisition System to monitor and record specific operational parameters inclusive of those identified above. An Engineer approved, calibrated system with real-time access to the collected data shall be provided to Engineer at the Contractor's expense.

3.3 DRILLING FLUID MANAGEMENT

A. General
1. Contractor is responsible for obtaining, reporting (per shift of operation) of volumes, transporting, and storing any water required for drilling fluids. Engineer must review and approve water source(s) identified by Contractor prior to use.
2. Drilling fluid management, including generation, storage, and disposal, shall be in accordance with the applicable state requirements and guidance for drilling fluids disposal, as identified in the Contract Documents.

B. Instrumentation
1. Provide and maintain instrumentation that will accurately measure drilling fluid discharge rate and pressure. Engineer shall have access to these instruments and their readings at all times.

C. Drilling Fluid Pressures and Circulation
1. Take necessary precautions to ensure the drilling fluid pressure in the drilled hole does not exceed what can be contained by the formation to reduce the potential for migration into water bodies, wetlands, utilities, foundations, structures, road and railroad rights of way, or other facilities.
2. Make every effort to maintain full annular circulation of drilling fluid and recycle the drilling fluid throughout the drilling process. Where recycling of drilling fluid is not practical, make every effort to direct drilling fluid dispersed to designated excavations such as the returns pits at the crossing endpoints. All drilling fluid and cuttings directed to these alternative locations must be gathered and collected within the designated excavations, or as otherwise approved by the Engineer.
3. Utilize a downhole annular pressure tool for recording and reporting maximum and average annular pressure on each joint completed during pilot hole. When annular pressure(s) are observed that may compromise and/or exceed formation limit pressures, make every effort to reduce downhole annular pressures and to maintain full annular circulation without inducing a hydraulic fracture and/or inadvertent returns.
4. If annular circulation is lost and drilling fluid returns are not flowing to designated excavations, take steps to restore circulation. If inadvertent surface returns of drilling fluids occur, they shall be immediately handled per the agreed upon contingency plan for inadvertent drilling fluid migration and release. If the amount of surface return exceeds what can be handled per the pre-approved contingency plan, suspend drilling operations until surface return volumes can be controlled, or an alternative plan can be implemented.

D. Drilling Fluid Containment
1. Provide suitable containment for all drilling fluids resulting from the drilling operation. Ensure all drilling fluids are contained within the drilled hole, the endpoint excavations, or any fluid tanks used for recirculating fluid.

E. Plan for Drilling Fluid System
1. CONTRACTOR shall submit a job specific plan of the proposed drilling fluid mixing system, cleaning system, and drilling fluid pumping capabilities in its Drilling Plan. At a minimum, the plan shall include the following information:
a. Total volume of mixing tank – (BBLS);
b. Total volume of cleaning tank – (BBLS);
c. Scalping shakers – quantity;
d. Scalping shakers – mesh size;

e. Desander cones – quantity;
f. Desander cleaning ability – GPM;
g. Desander shakers – mesh size;
h. Desilter cones – quantity;
i. Desilter cleaning ability – GPM;
j. Desilter shakers – mesh size;
k. Centrifuge(s) – quantity;
l. Centrifuge(s) cleaning ability – GPM;
m. Drilling fluid pump(s) capabilities (for both entry and exit sides): name brand, liner size, maximum pressure, maximum flow rate (GPM), and gallons per stroke;
n. Anticipated drilling fluid pump volumes (GPM) to be maintained on each reaming pass, per subsurface conditions identified for project;
o. Size(s) and type(s) of centrifugal pit pumps or submersible pit pumps;
p. Anticipated quantity of water required for drilling operations with estimated maximum daily rate to be consumed;
q. Drilling fluid containment sites and volumes.

3.4 DRILLING FLUID PROPERTIES

A. General
1. Composition of drilling fluids and products utilized shall be in accordance with the applicable state requirements and guidance for drilling fluids disposal, as identified in the Contract Documents. Contractor shall adhere to any additional site-specific requirements.

B. Drilling Fluid Engineer
1. Provide a certified Drilling Fluid Engineer on-site (one Engineer per shift of operation) during all phases of the drilling process. Contractor shall be responsible for these costs.

C. Plan for Drilling Fluid Composition
1. Provide, as a component of the Drilling Plan, a description of the drilling fluid composition to be used. The drilling fluid composition shall be determined by the Contractor's drilling fluid engineer(s). The Engineer reserves the right to prohibit the use of materials it deems unsuitable for proper performance of the work or when considered noncompliant with project permits.
2. The drilling fluid composition plan shall include the following information:
   a. Anticipated drilling fluid composition with SDS sheets, including all proposed additives;
   b. Minimum and maximum viscosities that will be maintained in the anticipated formation(s) to be encountered;
   c. Proposed ideal and maximum percentage of solids (including sand content) to be maintained during all phases of the drilling process. Describe the process that will be implemented should the percentage of solids exceed the proposed maximum;
   d. Proposed ideal and maximum drilling fluid density to be maintained during the drilling process. A description of the process that will be implemented should the drilling fluid density exceed the proposed maximum.
3. Submit for Engineer's approval SDS sheets for any changes to the drilling fluid composition or use of additives during construction. Engineer must approve any changes prior to use of the new product(s) and/or drilling fluid additive(s).
4. Any additives not included in the plan shall NOT be allowed on-site or used without Engineer's approval.

D. Reporting of Drilling Fluid Properties
1. Check drilling fluid properties at least six times per 12-hour shift during all phases of drilling operations. The results of these tests shall be recorded during each shift and a copy of the report shall be given to Engineer at the end of each shift. The report shall include the following or as otherwise approved by Engineer:
   a. Daily total of Bentonite used and total to date;
   b. Drilling fluid additives in use;

c. Density ('mud weight', per API RP 13B-1);
d. Rheology (including apparent viscosity, plastic viscosity and yield point per API RP 13B-1);
e. Funnel Viscosity (using Marsh funnel, per API RP 13B-1);
f. Gel Strength (per API RP 13B-1);
g. Solids and Sand Content (per API RP 13B-1);
h. Water loss (filtration, per API RP 13B-1);
i. Chemical quality of make-up water and drilling fluid (e.g., pH, chlorides, hardness, per API RP 13B-1).

3.5 DISPOSAL OF DRILLING FLUID AND CUTTINGS

A. General
1. Promptly remove all waste drilling fluids and associated cuttings collected from job site and haul to an Owner approved facility for proper disposal. Disposal costs shall be borne by the Contractor. Contractor is responsible for all work necessary for disposal and/or containment within the designated area, including any improvements to the property and including improvements necessary for ingress and egress to the site, and is responsible for all work necessary to clean up and restore property used for beneficial reuse. Contractor shall bear all costs to clear additional disposal sites requested by the Contractor and approved by Owner.
2. Obtain and maintain current permits for disposal of all solid and liquid wastes at each Owner-approved disposal location.
3. Maintain a steady supply of equipment to keep up with the volume of drilling fluid disposal (drilling fluid, soil, and cuttings) requirements;
4. At any designated location for which containment and disposal of drilling fluid and cuttings has been approved, ensure drilling fluid and/or cuttings do not escape the designated area. Means and methods for directing drilling fluid into, or out of, the prescribed locations is the Contractor's responsibility.

B. Plan for Disposal of Drilling Fluids and Cuttings
1. For any drilling fluid and cuttings requiring disposal, include in the Drilling Plan a disposal management plan for excess drilling fluid and cuttings. Notify Engineer of any proposed changes to the plan for approval prior to work starting and throughout construction. At a minimum, the disposal plan shall include:
a. Description of plans for disposal of the drilling fluid and cuttings;
b. Drilling fluid disposal and/or containment sites;
c. Names, addresses, and telephone numbers of subcontractors to be performing any portion of the disposal activities;
d. Disposal location (to be in compliance with applicable Owner's permits and/or a Owner's authorized location) for disposing drilling fluid and cuttings or other project wastes;
e. Travel corridors (including alternative routes) to and from the workspace and disposal locations;
f. Anticipated intervals for disposing of the drilling fluid (duration between loads and volume per load);
g. Disposal hauling vehicle(s) and vessel(s);
h. Estimated quantities of drilling fluid and cuttings to be disposed of;
i. Estimated quantities to be contained in designated containment sites;
j. Remediation plan for restoration of the containment sites.

C. Disposal Reporting
1. Submit daily reports to Engineer, including the following:
a. Quantity of liquids and solids hauled or transferred away from drill sites;
b. Physical description of the solids and liquids (drilling fluid, cuttings, hazardous waste, etc.)
c. Bill(s) of lading/trip ticket(s) for each load hauled off and/or disposed of;
d. Lab sample results in accordance with local disposal permits, if applicable.

2. Total solids and liquids disposal quantities shall be reported for each disposal site used throughout construction.

3.6 INADVERTENT DRILLING FLUID MIGRATION AND RELEASE

A. General
   1. Immediately cease drilling and notify Engineer upon detection of drilling fluid-release to the ground surface, water body, or any other sensitive site. Operations shall not resume without Engineer's approval.
   2. Have adequate spill containment measures and collection equipment on site at all times to properly execute the approved contingency plan for inadvertent drilling fluid release.
   3. All areas contaminated by drilling fluid shall be cleaned up and restored to the original condition, meet and/or exceed agency requirements, or as accepted by the Engineer, at Contractor's expense.
   4. Contractor is responsible for damages to structures, foundations, pavements, utilities and/or other facilities affected by drilling fluid migration. Owner's approval shall be required before any remediation efforts are considered complete and acceptable.

B. Contingency Plan for Drilling Fluid Migration and Release
   1. Submit a site specific plan for containing, collecting, and cleaning up after inadvertent drilling fluid migration and release as part of the Drilling Plan. At a minimum, the contingency plan shall include:
      a. Monitoring procedure for detecting and/or identifying loss of circulation indicators;
      b. Procedures for monitoring fluid pressure and ranges for acceptable annular pressure;
      c. Decision points and procedures for suspending drilling operations;
      d. Detailed descriptions of all equipment to be used for monitoring, such as the downhole annular pressure tool;
      e. Materials to be utilized for drill continuance such as plugging agents, lost circulation materials, etc.
      f. A list of any pre-identified sensitive areas near the alignment where access and/or methods for containment and cleanup may be limited with proposed plans for addressing the limitations;
      g. Protocols and procedures that will be in place to enhance focus on preparedness and prevention of inadvertent returns;
      h. An inventory of equipment and materials to be on site for containment/cleanup;
      i. Containment methods.

C. Reporting of Drilling Fluid Migration and Releases
   1. Submit a report (for each instance) of quantity of drilling fluid released, specific location, phase of operation at which time the event occurred, description of operational conditions, and clean up activity.

3.7 CASING

A. If a casing pipe is required or determined necessary, the following shall apply:
   1. Casing shall be installed into a competent formation that will enable the drilling operations to proceed with minimal loss of drilling fluid at this interface.
   2. Large diameter casing shall be sized adequately to ensure the planned reaming passes can be completed with the casing in-place.
   3. Casing centralizers shall be included in large diameter casing to facilitate the reaming tools and assemblies for entering into the casing.
   4. For large diameter casing, the planned timing and techniques for removal of the casing must be approved by Engineer prior to pullback. Removal prior to pullback and/or post pullback may be approved but is at the discretion of the Engineer.
   5. All concerns associated with the casing(s) presence shall be addressed prior to demobilization and all casings must be removed, unless otherwise approved by the Engineer.
   6. Provide qualified welders to complete welds on the casing.

7. Engineer reserves the right to require approved non-destructive testing (NDT) completed on all casing welds at the expense of the Contractor.
8. Grout the annulus between the extracted casing and the installed conduit.
9. Prepare a Casing Plan and submit to Engineer as part of the Drilling Plan. At a minimum, the Casing Plan shall include:
    a. Location for casing installation;
    b. Anticipated schedule for casing installation;
    c. Length, diameter, wall thickness, and tensile strength;
    d. Methods of installation, anchoring, grouting, and removal; and
    e. Details of centralizers and plan for loading and unloading relative to each phase of drilling operation.

3.8 PILOT HOLE DRILLING, TRACKING, AND SURVEY

A. General
    1. At all times, provide and maintain instrumentation to document and accurately locate the pilot hole, to measure drill-string axial and torsional loads, and to measure drilling fluid discharge rate and pressure. Engineer shall have access to these documents and instruments, along with their readings at all times.
    2. The pilot hole shall be drilled within the specified tolerances along the path shown on the plan and profile drawing. The position of the drill string shall be monitored with precise downhole survey instruments and verified with secondary survey location equipment (i.e. TruTracker, ParaTrack, or equal).
    3. Where surface location equipment is not practical, a gyroscopic steering tool or alternative Engineer-approved technology shall be used for the primary and/or secondary survey.
    4. Provide a description of its downhole survey instruments and surface location equipment and provide a sketch of the coil layout (as applicable) with its Drilling Plan for Engineer approval. Where practical, there shall be no gap in tracking coverage for the entire length of drill path. If a surface tracking system is used, install coils over or under obstacles.
    5. The following information shall be recorded prior to commencing the pilot hole operations:
        a. Surveyed elevation and location of the actual ground surface at the endpoints and comparison to the design drawing;
        b. Distance from the drill bit to the down-hole steering tool sensors;
        c. Distance from the rig's pipe break-out point to the entry point;
        d. Length and description of the complete bottom hole assembly including; motor, bit, orienting sub and non-magnetic pipe, etc.
    6. Compute the position in the X, Y, and Z-axes relative to ground surface from down-hole survey data a minimum of once per length of each joint drilled or jetted (approximately 30-foot interval). Upon exit of the pilot hole bit, take the final survey with the steering tool at the ground elevation. This survey shall be tied-in to the existing exit survey stake.

B. Plan for Pilot Hole Execution
    1. Submit a plan for the execution of the pilot hole as part of the Drilling Plan. At a minimum, the following information shall be provided:
        a. Confirmation of, and agreement to, HDD design(s) including route, profiles, depth of cover, penetration angles and Engineer-approved minimum radius of curvature, or proposed alternatives. If modifications are proposed, submit detailed plan and profile designs depicting the proposed changes for Engineer's review and approval. Written approval by Engineer must be obtained for any modifications to the design in the Contract Documents to be executed;
        b. Anticipated and maximum penetration rates and drilling fluid pump volumes to be maintained for the geotechnical formation expected for the crossing;
        c. Type of pilot hole bits (include diameter, type, and historical usage time) and serial numbers for each bit;
        d. Type of pilot hole survey equipment to be utilized and its stated accuracy; and
        e. A sketch of surface tracking system coil layout (as applicable) and/or alternative tracking devices and their locations proposed for completing the pilot hole.

f. Contractor shall submit documentation showing steering tool calibration has been implemented prior to pilot hole operations and subsequent roll test(s) shall be completed during pilot hole operations if the steering tool is tripped out for any reason.

C. Entry/Exit Angle, Horizontal Alignment, and Depth

1. The entry and exit points will be staked on the ground or identified as shown on the plan and profile drawing and shall be located by the Contractor using traditional and/or GPS survey methods. If site grading is required at entry or exit, Engineer will work with Contractor to determine the impact and assess the need for providing new coordinates for the entry or exit point.
2. Prior to construction, perform a survey evaluation of the proposed crossing at the specified location to verify the locations shown on the Contract Documents drawings. The survey shall include verification that the location of the HDD entry point(s), the azimuth along the alignment, and the drill exit location(s) are in accordance with the approved drilling plan. If the Contractor detects any discrepancies, they shall notify the Engineer immediately. All benchmarks, survey monuments, and other positioning stations shall be maintained.
3. Pilot hole drill path shall follow the path shown on the approved drilling plan and as listed in the table below:
4.

Item	Tolerance
Pilot entry angle	Increase angle up to 1° (steeper) or decrease up to 1° (flatter).
Pilot entry location	As defined on the approved drilling plan. No change without Engineer's approval.
Pilot exit angle	Increase angle up to 1° (steeper) or decrease up to 2° (flatter).
Pilot exit location	Up to 10 feet longer or 10 feet shorter than the exit point at the bottom of exit excavation. Between 3 feet left and 3 feet right of HDD centerline shown on the approved drilling plan.
Pilot depth	Up to two (2) feet above the designed drill profile or up to 10 feet below the designed drill profile.
Pilot alignment	Shall remain within 3 feet left or right of the HDD centerline shown on the drawings.

D. Pilot Hole Radius

1. The pilot hole shall be drilled at a radius equal to that shown on the plan and profile drawing. Deviations and corrections made along the drill path shall not exceed the absolute minimum vertical, horizontal, and combination radius over a three-joint range as shown on drawings.
2. Calculate the vertical, horizontal, and combination drilled radius over all consecutive three-joint segments using the following formula (assuming range 2 drill pipe):

$$\mathbf{R}_{drilled} = (\mathbf{L}_{drilled}/\boldsymbol{\theta}_3) * \mathbf{180}/\boldsymbol{\pi}$$

Where:

$\mathbf{R}_{drilled}$ = radius of curvature in feet over $\mathbf{L}_{drilled}$
$\mathbf{L}_{drilled}$ = length in feet over any three joints of drill pipe
$\boldsymbol{\theta}_3$ = change in angle over $\mathbf{L}_{drilled}$ in degrees
$\mathbf{180}/\boldsymbol{\pi}$ = unit conversion from radians to degrees = 57.2957795139

Combined radius values shall be calculated as follows:

$$R_{combined} = (R_{vertical}^2 * R_{horizontal}^2)/(R_{vertical}^2 + R_{horizontal}^2)$$

Where:

$R_{combined}$ = combined three-joint radius
$R_{vertical}$ = vertical three-joint radius
$R_{horizontal}$ = horizontal three-joint radius

E. Pilot Hole Survey Reporting
   1. Deviations between the recorded position of the drill string and the plan and profile drawing, resulting in out-of-project-tolerance and/or radius violations shall be documented and immediately brought to the attention of Engineer. Correction of any deviations shall be at Contractor's sole expense.
   2. Provide in the daily report (i.e. per each shift of operation) to Engineer the computer printout of the directional survey; TruTracker, ParaTrack, or equivalent; and data verification reports generated by the downhole survey tool's software. Report data shall be in a format suitable for independent evaluation of the pilot hole profile. Vertical and horizontal deviations from the designed drill path shall be reported at each surveyed location to ensure the drilled path is within the specified pilot hole tolerances. With each shift's reporting, provide an "as-built" drawing (e.g. AutoCAD and printed to PDF) to represent pilot hole progress to date, any abandoned holes, tools, strings of drill pipe, etc., all overlaid on the plan and profile drawing in the Contract Documents. Engineer reserves the right to request this information at any time or during any shift. Contractor shall provide this information with no additional cost to Owner, even should the pilot hole drilling operation be halted to provide this information.
   3. Also provide the following to Engineer in the daily report:
      a. Maximum torque and push/pull values observed and recorded on each joint drilled. Note reasons for any excessive torque or push force value beyond normal operating conditions;
      b. Penetration rates for each joint drilled/jetted;
      c. Surveyed position of the steering tool on each joint, including azimuth, inclination, elevation, and right/left position relative to the design centerline;
      d. Calculated vertical, horizontal, and combination radius of each three-joint segment of the pilot hole.
   4. At the completion of the pilot hole drilling and prior to initiating the reaming phase of operation, provide a complete tabulation of horizontal and vertical coordinates referenced to the drilled entry point, which accurately describe the location of the pilot hole drill path. Provide an "as-built" drawing (e.g. AutoCAD and printed to PDF) to represent pilot hole locations, any abandoned holes, tools, strings of drill pipe, etc., overlaid on the plan and profile drawing in the Contract Documents within 10 days of pilot hole completion.

F. Pilot Hole Corrections
   1. Re-drill or pullback and correct the pilot hole to maintain a drill path within the project tolerances. Provide documentation for verifying the pilot hole is within the specifications.
   2. Contractor is responsible for all costs associated with re-drilling of any portion of the pilot hole, including grouting of abandoned pilot hole(s), or alternative Engineer--approved practice.

3.9 HOLE REAMING

A. General
   1. Meet with the Engineer and review pilot hole data before the hole-opening process begins. Do not proceed with reaming the hole until the Engineer has approved the pilot hole.

B. Reaming Plan
   1. Submit a reaming plan as part of the Drilling Plan, which shall include but is not limited to:

a. Size and type of hole opening tools (provide historical usage time and serial numbers);
    1) All tooling condition must be documented prior to and post hole entry and exit.
b. Number of reaming and swab passes (include size, direction, and any additional relevant information for each pass);
c. Anticipated and maximum penetration rates and pump volumes to be maintained for the geology anticipated for the project, as well as, in clay, sand, silt, rock, and gravel; and
d. Final hole size.

2. Any proposed changes to Engineer-approved reaming plan resulting from operational observations during construction shall be submitted to Engineer for review and approval prior to implementation.

C. Lost or Lodged Tools
1. Any tools or other metal object(s) lost or lodged downhole shall be reported to the Engineer as soon as possible. All metal objects shall be fully recovered prior to the pipe pullback operation, unless specifically approved by Engineer. Fishing tools shall be of adequate size and ability to capture lost tooling. Failure to recover metal objects lost or lodged downhole within a reasonable time period may constitute just cause for rejection of the drilled hole.

3.10 CONDUIT PREPARATION AND PULLBACK

A. Pipe Material Properties
1. Maximum Pulling Force:
    a. Submit calculations determining the maximum pulling force that may be anticipated during the pullback operation to overcome theoretical frictional forces.
        1) Calculations shall be stamped by a Professional Engineer licensed in the State of Washington and accompanied by written approval from the pipe manufacturer verifying that the maximum calculated pulling force will not exceed the manufacturer's recommended yield tensile strength and factor of safety for the proposed pipe material and fused joint.
2. Radius of Curvature:
    a. Submit the radius of curvature planned for the installation of the pipeline along with calculations showing that installation stresses do not exceed allowable stress. Use a minimum factor of safety of 2.0 to determine the allowable stress.
3. Submit calculations for thrust, torque, and pullback loads for the conditions and operating practices anticipated.

B. Pullback Preparation and Execution Plan
1. Submit a plan for the preparation and execution of pulling the conduit into the final reamed hole as part of the Drilling Plan. At a minimum, the following information shall be provided (as applicable for the crossing per the contractor's means and methods):
    a. Procedural outline, including timeline of events;
    b. Expected pulling loads (include out-of-hole, in-hole, and maximum overall pull loads);
        1) Capabilities and capacity of the rig used to pull the pipe;
        2) Lift equipment and HDD rig anticipated pullback forces to be exerted; and
        3) Anchoring procedures as required.
    c. Equipment and tooling capacities and configurations to be utilized for the pullback assembly and pullhead;
        1) Barrel reamer(s), hole openers, rock shields, swivel, u-joints, shackles, pullhead, etc.; and
        2) Condition of equipment and loading certificates.
    d. Casing removal and pull-through plan;
    e. Drilling Fluid Management Plan;
    f. Pullback assembly/pullhead connection including equipment type, size, and positioning for execution. A support plan for pulling the conduit up to the drilled hole prior to installation shall be included;
    g. Types of equipment anticipated for use and support for handling the conduit during pullback. Plan for conduit fabrication, testing (if required in the Contract Documents),

and pullback support. Number and sizes(s) of pullback equipment (i.e. number of side booms, cranes, and other support equipment);
    1) Lifting plan including bending radius calculations for the above-ground pull string accounting for the as-drilled exit angle and actual ground surface behind exit at the time of construction;
    2) Pipe supports and roller spacing; and
    3) Buoyancy control plan (if to be applied), including control volumes, fill rates, filling methods, etc.
h. Plan for making any mid-pullback fuses, including locations behind exit where the connections will be made;
i. Pullback rates;
j. Contingency Plans;
    1) Methods and equipment used in the event the conduit becomes stuck during pullback; and
    2) Pipe abandonment.
k. PSE will pull cables though installed conduit. Contractor to remain on site during pulling of cables post-installation of the conduit.

C. Pipe Preparation Prior to Pullback
1. The pipe and fuses shall be inspected during fabrication, and immediately prior to setting the pull string in its pre-designated location.
2. Provide a pullhead of suitable condition, strength, and durability to withstand the anticipated external loads during pullback. The pullhead shall be readily available onsite for installation onto the conduit so there are no delays in the pipe preparation process.
3. To minimize torsional stress imposed on the pull section, use a swivel assembly with sufficient capacity for overcoming all potential pull loads that may be exerted for connecting to the pull section. The swivel shall be recently greased prior to pullback and in acceptable working condition.
4. In addition to inspection requirements for all conduit pullback string fuses, Engineer may require inspection on the fused connection between the pullhead and leading end of the conduit.

D. Pipe Pullback
1. During pullback, the conduit above ground shall be supported in accordance with the approved pullback plan. Ensure the conduit string moves freely on the support equipment cradles, rollers, reels, etc.
2. Provide and maintain instrumentation that will accurately measure drill string axial and torsional loads. Engineer shall have access to these instruments and their readings at all times. The maximum permissible tensile load imposed on the pull section shall be less than the safe pull load reported by the HDPE pipe's manufacturer when accounting for axial stress limits (tensile and bending included).
3. Ensure pulling forces do not exceed what the anchored rig can safely withstand. If higher pulling forces are anticipated, implement supplemental support systems for anchoring the equipment with Engineer approval prior to installation.
4. Do not use any hammering or ramming device to aid in the installation of the pipeline. If any pneumatic hammering or ramming devices are used to progress or extract pipe, the entire portion of pipe exposed to the process shall not ever be utilized for product pipe. It shall be removed and replaced without pneumatic means.
5. Install the pipeline in one continuous string with no mid-pullback fuses, unless stated otherwise in the approved Drilling Plan. Make every effort to minimize time between the final ream pass and pullback while ensuring the hole is conditioned and suitable to receive the HDD conduit through one or more successful swab passes. Pullback shall commence immediately after the final (successful) swab pass has been completed. Once the pullback operation begins, installation shall not cease until pullback operations are completed unless otherwise approved by the Engineer.

6. Modifications to the buoyancy control plan approved for the project shall be used at Contractor's discretion. Any buoyancy control modification procedures proposed for use shall be submitted to Engineer for approval prior to any modifications being started. No procedure may be used that Engineer has not approved. Contractor is responsible for any damage to the pipeline resulting from buoyancy control modification(s).
7. Utilize equipment necessary to lift the pullback section up to match the as-drilled exit angle as the conduit enters the reamed hole, and safely support the pipeline in the break over area.
8. If the conduit pull section becomes lodged in the drilled hole during pullback and cannot be recovered, seal the pipe and existing drilled hole.
9. In the event of failed pullback with abandoned conduit downhole, redesign the crossing. Do not initiate any repeat efforts to install conduit by HDD until Engineer approves the revised design. Contractor shall bear all costs of re-design, re-drilling, pipe fabrication, and testing (if required by the Contract Documents) to replace any pipe that is not retrieved from an unsuccessful pullback.
10. The pull section shall be installed in the enlarged hole so that pipe stresses are minimized. Any damage to pipe resulting from external forces during installation shall be Contractor's responsibility.
11. The leading end of the HDD conduit shall be pulled out beyond the entry point a sufficient length so that the pipe does not recede back into the hole once the tension is released from the rig and to be cleaned and visually inspected by the Engineer prior to disconnecting the pullhead from the pullback assembly.

3.11 TESTING, INSPECTIONS, AND ACCEPTANCE

A. Acceptance of Installation
   1. Engineer will review results of the pilot hole survey information, post-installation test data (as required), and any material inspection data and then determine the acceptability of the installed HDD crossing. Engineer shall notify the Contractor of the final results.

B. Final Reporting
   1. Compile all daily reports, project documentation, and as-built files into a Final Project Report that shall be submitted to the Engineer within 10 days after completion of construction.
   2. Furnish to Engineer a copy of the complete computer printout of the directional survey; TruTracker, ParaTrack, or equivalent; and data verification reports made during the drilling operation. Also provide a plan and profile as-built map of the horizontally drilled section showing the X, Y, and Z coordinates of the final pipeline location. The maximum spacing between coordinate points shall be every joint of drill pipe (approximately every 30 feet).
   3. Furnish the as-built drawing within 10 days after the completion of the pilot hole. The "as-built" drawing must be submitted in both AutoCAD and printed to PDF, representing final approved pilot hole data, any abandoned holes, tools, strings of drill pipe, etc. overlaid on the plan and profile drawing in the Contract Documents.
   4. All data reports and as-built drawings shall be included as part of a comprehensive Final Project Report as required.

3.12 DEMOBILIZATION

1. Do not demobilize equipment from the job site until approved by the Engineer.

3.13 SITE CLEANUP AND RESTORATION

A. Grouting and Sealing of Annulus and Abandoned Holes
   1. Furnish and inject cement grout into the annulus at entry and exit of completed HDD. The minimum extent of the grouting will be to completely seal and fill the upper 30 linear feet of hole (immediately below tie-in elevation) entirely with grout and a minimum of the top 5 vertical feet filled with backfill material to match surrounding soil conditions. More extensive grouting may be required to prevent ground subsidence or comply with permit requirements, as defined by the Engineer—all of which shall be the responsibility of the Contractor.

B. Backfill of Endpoint Excavations
   1. Backfill of excavations shall not commence until approved by the Engineer.

C. Remediation of Ground Subsidence and Voids
   1. Check for voids along all attempted drill paths and the final HDD corridor that are within dry land (not in stream). Fill voids and compact subsoil along installed pipeline and along any abandoned drill path. Restore ground above HDD corridor to original contours and condition including furnishing and installing Engineer-approved fill materials at no additional cost to Owner.

D. Clean Up and Restoration
   1. Remove all equipment, materials, debris, temporary markers, and other remnants of construction, including trash, and then perform final clean up to restore all work areas in accordance with Contract Documents. Restoration shall include temporary and permanent re-vegetation as applicable and/or as specified in the drawings and Contract Documents.