



AECOM Technical Services, Inc.
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Phone: (803) 254-4400

Sent via Email
March 11, 2025

**RE: Lime Slurry Feed System For The Lyall Street Water Treatment Plant
City of Bennettsville, South Carolina
Project No. 60753190**

ADDENDUM NO. 1 – MARCH 11, 2025

TO: ALL HOLDERS OF RECORD OF CONTRACT DOCUMENTS

Acknowledge receipt of this addendum by inserting its number and date in the Bid Form. Failure to do so may subject bidder to disqualification. This addendum forms a part of the Contract Documents. It modifies them as follows:

SPECIFICATIONS

1. SECTION 00005 – HUD-CDBG TABLE OF CONTENTS

Add Section 00900 – BABA Bidders Certification. Form is attached.

List of Approved Suppliers can be accessed at: <https://www.nist.gov/mep/supply-chain/supplier-scouting>

2. SECTION 00020 – ADVERTISEMENT FOR BIDS

Change bid date from 2 PM on March 17, 2026 and replace with **“2 PM March 31, 2026”**.

Replace paragraph 10 entirely with **“*Bidding Documents may be viewed and ordered online by registering with Duncan Parnell via their bid room <https://bidroom.duncan-parnell.com/>. Registration with Duncan Parnell is required to obtain the bid documents and be added to the official Plan Holder’s List. Addenda will only be notified to those buying full sets from Duncan Parnell via their bid room. The cost of bid documents and shipping is non-refundable. The City of Florence / AECOM will NOT be responsible for copies of the bid documents obtained from sources other than from Duncan Parnell. If you need any assistance ordering or getting registered on <https://bidroom.duncan-parnell.com/> please contact: Michaela Bruinius at constech@duncan-parnell.com or 704-526-1856.”***

3. SECTION 00100 – INFORMATION FOR BIDDERS

Delete “Any and all such interpretations and any supplemental instructions will be in the form of written addenda to the specifications which, if issued, will be mailed to all prospective bidders (at the respective addresses furnished for such purposes)”

Replace with “***Any and all such interpretations and any supplemental instructions will be in the form of written addenda to the specifications which, if issued, will be emailed by keiran.ryan@aecom.com to all prospective bidders (at the respective addresses furnished for such purposes)***”.

4. SECTION 00311 – BID FORM

Replace form entirely with the attached.

5. SECTION 00900 – BABA CERTIFICATION FORM

Insert form attached.

5. SECTION 13491 – PROCESS CONTROL DESCRIPTIONS

Replace form entirely with the attached.

6. SECTION 16400 – ELECTRICAL

Replace form entirely with the attached.

END OF ADDENDUM NO. 1

SECTION 00311

BID FORM

LIME SLURRY FEED SYSTEM
FOR THE LYALL STREET
WATER TREATMENT PLANT

FOR THE CITY OF BENNETTSVILLE, SC

CDBG PROJECT NO.: 4-CI-24-001

Date: Bennettsville, SC
Project No. 60753190

PROPOSAL OF _____,

doing business as a corporation / a partnership / an individual (Strike out inapplicable terms),
with its principal office in the City of _____, County of _____, State of
_____, (hereinafter called "Bidder").

TO: City of Bennettsville
(hereinafter called "Owner"),

To all potential bidders:

The Bidder, in compliance with your invitation for bids for the construction of the Lime Slurry Feed System for the Lyall Street Water Treatment Plant having examined the plans and specifications with related documents and the site of the proposed work, and being familiar with all of the conditions surrounding the construction of the proposed project, including the availability of materials and labor, hereby proposes to furnish all labor, materials and supplies, and to construct the project in accordance with the Contract Documents, within the time set forth therein, and at the prices stated below. These prices are to cover all expenses incurred in performing the work required under the Contract Documents, of which this proposal is a part.

Bidder hereby agrees to commence work under this contract on or before a date to be specified in written "Notice to Proceed" of the Owner and to fully complete the project within 240 consecutive calendar days thereafter as stipulated in the specifications. Bidder further agrees to pay as liquidated damages the sum of \$500 for each consecutive calendar day thereafter as hereinafter provided in Paragraph 19 of the General Conditions.

The drawings, specifications and addenda are complementary of each other. What is called for by one shall be as binding as if called for by all. If a conflict between any of the above is discovered by the contractor, the problem shall be referred to the Engineer as soon as possible for resolution by the Engineer. Should a conflict occur which is not resolved before bid time and/or is necessary to comply with mandatory requirements (i.e., codes, ordinances, etc.), it shall be the contractor's responsibility to price and bid the more expensive method.

Bidder acknowledges receipt of the following addendum:

No. _____ Dated _____ No. _____ Dated _____
 No. _____ Dated _____ No. _____ Dated _____

Bidder agrees to perform all of the _____ described in the specifications and shown on the plans for the following sump sum prices:

Item No.	Est Qty	Unit	Description	Unit Price	Total	Production Location (USA)
1.	1	EA	Mobilization/Insurance	\$	\$	
2.	1	EA	Equipment Start-up, O&M Manuals	\$	\$	
3.	1	EA	Erosion & Sediment Control	\$	\$	
4.	1	EA	Service Water & Drain Piping, Valves & Appurtenances	\$	\$	
5.	1	EA	Site Work	\$	\$	
6.	1	EA	Lime Slurry Equipment Pad and Above Ground Drainage Structure	\$	\$	
7.	1	EA	Chemical Feed Piping	\$	\$	
8.	1	EA	Chemical Feed & Taps	\$	\$	
9.	1	EA	Caustic Day Tank, Equipment, Piping, & Feed Pump Demolition	\$	\$	
10.	1	EA	Lime Slurry System	\$	\$	
11.	1	EA	Electrical Work	\$	\$	
12.	1	EA	SCADA System	\$	\$	
13.	1	EA	Painting	\$	\$	
14.	1	EA	Pre-cast Chemical Concrete Pull Box Equipment, Piping & Installation	\$	\$	
15.	60	LF	Chain Link Fence	\$	\$	
TOTAL OF BID:				\$		

The above unit prices shall include all labor, materials, bailing, shoring, removal, overhead, profit, insurance, etc., to cover the finished work of the several kinds called for.

The Bidder declares that he understands that the quantities shown in the Proposal are subject to adjustment by either increase or decrease and that should the quantities of any of the items of the work be increased, the undersigned proposed to do the additional work at the unit prices stated herein, and should the quantities be decreased, he also understands that payment will be made on actual quantities at the unit price bid, and will make no claim for anticipated profits for any decrease in the quantities and that actual quantities will be determined upon completion of the work, at which time adjustment will be made to the contract amount by direct increase or decrease.

Bidder understands that the Owner reserves the right to reject any or all bids and to waive any informalities in the bidding.

The Bidder agrees that this bid shall be good and may not be withdrawn for a period of _____ calendar days after the scheduled closing time for receiving bids.

Upon receipt of written notice of the acceptance of this bid, Bidder will execute the formal contract attached within 10 days and deliver a Surety Bond or Bonds as required by Paragraph 30 of the General Conditions. The bid security attached in the sum of _____ Dollars _____ Cents (\$ _____) is to become the property of the Owner in the event the contract and bond are not executed within the time above set forth, as liquidated damages for the delay and additional expense to the Owner caused thereby.

By submission of this bid, each bidder certifies, and in the case of a joint bid, each party thereto certifies as to its own organization, that this bid has been arrived at independently, without consultation, communication, or agreement as to any matter relating to this bid, with any other bidder or with any competitor.

[SEAL – (If bid is by a corporation)]

Respectfully submitted:

BY: _____

(Print Name)

(Title)

(Business Address)

Bidder's Build America, Buy America Act (BABA) Certification

Grant Number _____

Project Name _____

Federal Funding Agency _____

This project is subject to the Build America, Buy America Act (BABA) requirements under Title IX of the Infrastructure Investment and Jobs Act ("IIJA"), Pub. L. 177-58. Absent an approved waiver, all iron, steel, and specifically listed construction materials used in this project must be produced in the United States. This means that all manufacturing processes, from the initial melting stage through the application of coatings for iron and steel, and all manufacturing processes for construction materials-specifically listed, must occur in the United States.

Documentation of BABA compliance must be provided by the contractor for for all iron, steel, and specifically listed construction materials (1. Non-ferrous metals, 2. Lumber, 3. Plastic- and polymer-based composite building materials, pipe, and tube) used in the project. Written evidence from the manufacturer or supplier will be required that identifies the item purchased; affirms the location of manufacture as within the United States; and is signed by an authorized company representative.

Additional guidance on BABA compliance, waivers, and documentation requirements is provided in HUD Notice CPD-25-01, "Implementation of Build America, Buy America Requirements for HUD Federal Financial Assistance Programs" (January 17, 2025).

As a bidder for the project listed above, I certify that I have read, understand, and will comply with the "BABA" provisions as required by federal law. Furthermore, I understand that BABA provisions apply to any and all portions of this project, including subcontracted portions and that I certify to the best of my knowledge and belief that I will identify domestic sources of BABA covered products, provide verification documentation for BABA- compliance, and when needed provide waiver documentation per current guidance.

I further agree that I will complete and submit the Contractor & Subcontractor Build America, Buy America Act (BABA) Certification prior to the processing of any request for final payment.

I understand that a false statement on this certification may be grounds for rejection or termination of any award.

Signature of Bidder

Date

Printed Name and Title of Bidder

Name of Bidder's Company

Bidder's Company Address

Bidder's Telephone Number

SECTION 13491

PROCESS CONTROL DESCRIPTIONS

PART 1 - GENERAL

1.01 DESCRIPTION

- A. Contractor shall provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to configure the SCADA System to accomplish the functionality specified herein
- B. This section describes the general function and disposition of each primary process loop. The CSI shall provide additional functions as required to adhere to good control and engineering practices.
- C. The process control descriptions are written descriptions of the basic configuration and/or programming required to implement the sequential control of the plant's unit processes. Finalizing and tuning of strategies, as required, by the process characteristics shall be accomplished during start-up.

1.02 DEFINITIONS

- A. Local – monitoring and controls located at the piece of equipment.
- B. Remote – monitoring and controls located away from the piece of equipment (such as an MCC) and/or programmed in SCADA.
- C. RUNNING – discrete input obtained from auxiliary contacts (or data link registers) provided with the local motor control equipment (i.e., starter, VFC, RVSS, etc.) which shall close (or change value) when the equipment is running.
- D. HOA IN AUTO – discrete input obtained from a dry contact which indicates that the remote HAND-OFF-AUTO (HOA) selector switch is in the “AUTO” position to permit remote control by the SCADA system.
 - 1. If the HOA is in “HAND”, all software functions associated with that specific equipment shall not be available and PLC control of equipment shall be halted.
- E. FAULT – discrete input obtained from local motor overload and/or any other shut down mode such as seal-fail, over-temperature, low oil pressure, high vibration, etc.
- F. OPEN & CLOSED – discrete inputs obtained from limit switches indicating the position of a valve either opened or closed.

- G. HOA (hand-off-auto) – remote virtual selector-switch function that allows the operator to select the mode of operation in either “HAND” (for remote manual control) or “AUTO” (for remote PLC control).
 - 1. If the local HOA is in the “AUTO”, this function shall allow the operator to select to either control that equipment manually or allow the PLC to control automatically.
- H. S/S (start/stop) – remote virtual pushbutton function that allows the operator to manually start and stop equipment. Available if the local HOA is in “AUTO” AND the remote HOA is in “HAND”.
- I. SPEED S/P (setpoint) – remote virtual numeric function that allows the operator to enter a numeric value from 0 – 100% that sets the speed of the associated motor. If the operator enters a value greater than 100%, the HMI or OIT shall display an error message and the motor speed shall remain unchanged. Available if the local HOA is in “AUTO” AND the remote HOA is in “HAND”.
- J. OPEN/CLOSE – remote virtual pushbutton that allows the operator to manually open or close a valve, gate, etc. Available if the local HOA is in “AUTO” AND the remote HOA is in “HAND”.
- K. SELSW – remote virtual selector switch that allows the operator to manually select one or more devices. Selector switch may have more than two selections depending on the application. Available if the local HOA is in “AUTO”. Availability in remote mode will depend on application.

1.03 SUBMITTALS (NOT USED)

1.04 QUALITY ASSURANCE (NOT USED)

1.05 DELIVERY, STORAGE AND HANDLING (NOT USED)

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01 DESIGN REQUIREMENTS

A. General

- 1. Overall requirements of the PMCS operation are as described in the loop descriptions in these Specifications and Drawings.
- 2. Automated process control at each process area and/or packaged system shall continue to operate in the event of a network failure.
- 3. SCADA shall be implemented, such that the operator has the ability to perform local control (‘HAND’ operation) in the event of a process area PLC failure.

4. Owner will provide Ethernet addresses to the CSI. Coordinate Ethernet addresses with PSI as applicable.

B. Monitoring and Control

1. SCADA shall be implemented such that the operator has the ability to monitor and control every device that is connected to the plant-wide communications network from the operator's human-machine interfaces (HMI's) and operator interface terminals (OIT's).
2. SCADA programming shall allow the operator to easily change the operating setpoints of all equipment that is automatically operated by the Control System. The setpoint ranges shall be hard coded such that the operator may not be allowed to enter a setpoint that allows the equipment to operate out of the range or limits set forth by the equipment manufacturer. In addition, the HMI shall have a configuration screen that allows an operator with proper security privileges to reset each of the setpoints to the default values originally programmed in the system.
3. SCADA shall automatically discover and re-configure the setting and parameters of replacement devices connected to the PMCS (e.g., VFC, solid-state overloads, RVSS, etc.)

C. Alarm Conditions

1. SCADA shall alarm the system operator whenever an alarm condition is present on any piece of equipment connected to the PMCS. The CSI shall coordinate with the Owner to determine the desired priority level for all alarms as well as call-out/paging sequencing.
2. SCADA shall alarm the system operator when any equipment that was called to run by the PLC fails to start or stops running for any reason.
3. Notify the operator of the system alarms by providing audible notification as well as displaying the alarm on the HMI with all of the associated alarm details.
4. Have the ability to be acknowledged through any of the HMI workstations or operator interfaces connected to SCADA.
5. Notify the "on call" operator in the event that the alarm is not acknowledged within a period of time to be determined by the Owner. In the event the "on-call" operator does not acknowledge or clear the fault, the SCADA system shall continue calling operators on the configured call-out list until the alarm is acknowledged or cleared.

D. Data Archival

1. SCADA shall store each operation of every piece of equipment.
2. SCADA shall store each start, stop, reset, log on, logoff, and alarm acknowledgement that an operator performs.
3. SCADA shall store the value of each analog and digital tag/variable such that the operator can trend plant data.

3.02 ELECTRICAL LOOPS

A. LIME FEED SYSTEM

1. Provide PMCS programming and HMI for the Lime feed system monitoring and control as shown on the P&ID drawing.
2. The Lime Feed System includes the following processes:
 - a. One 15% -30% Lime Storage tank to provide Lime to two metering pumps.
3. Narrative:
 - a. The 15%-30% lime is pumped to the Chemical feed vault.
 - b. When the metering pump selector switch in the control panel is placed in Auto, it is ready to receive a remote Influent flow input signal (0-100%) from the remote plant integration system to the lime system PLC via Ethernet ghost bridge interface provided by the General Contractor.
 - c. The liquid Lime PLC shall send the 4-20 mA corresponding input to the metering pump to adjust the stroke length 0-100 percent and provide an output signal back to the Liquid Lime System PLC for monitoring.
 - d. The operator shall have the ability to select two setpoints for Lime Tank: Low level alarm and low low alarm to alert operators that chemical order/delivery is needed.

B. MIXERS CONTROL

1. 15%-30% Lime Tank: Mixer is manually controlled via an ON/ OFF switch located on LCP-LS-1.

3.03 CONTRACT CLOSEOUT

- A. Comply with the requirement specified in Section 01700 "Contract Closeout".

END OF SECTION

SECTION 16400

ELECTRICAL

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work included: Provide a complete electrical system as indicated on the Drawings, as specified herein, and as needed for a complete and proper installation.
- B. Related work:
1. Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and Sections in Division 1 of these Specifications.
 2. Section 05990 – Miscellaneous Metals.

1.2 ABBREVIATIONS

A	Ampere (Amps)	MCA	Minimum Circuit Amps
AFF	Above Finished Floor	MCC	Motor Control Center
AFG	Above Finished Grade	MCM	1000 Circular Mills (KCMIL)
AHJ	Local Authority Having Jurisdiction	MOCP	Maximum Over-current Protection
AIC	Amps Interrupting Current	N	Neutral
AFCI	Arc-Fault Circuit Interrupter	NEC	2011 National Electrical Code
ANSI	The American National Standards Institute	NEMA	National Electrical Manufacturers Association
BF	Ballast Factor	NFPA	National Fire Protection Association
Bkr.	Breaker	NIC	Not in Contract
C	Conduit	OSHA	Occupational Safety and Health Act
Ckt.	Circuit	PF	Power Factor
CRI	Color Rendering Index	PLC	Programmable Logic Controller
CU	Copper Conductor	PVC	Polyvinyl Chloride Conduit
DETD	Dual Element Time Delay Fuse	RGSC	Rigid Galvanized Steel Conduit
Disc.	Disconnect	RMS	Root Mean Square
Dn	Down	RTU	Remote Terminal Unit
EMT	Electrical Metallic Tubing	SCADA	Supervisory Control and Data Acquisition
FLA	Full Load Amps	SCCR	Short-Circuit Current Rating
FPM	Fuse per Manufacturer Requirements	SPD	Surge Suppression Device
FS	Federal Specifications	Sym	Symmetrical
G or	Ground	THD	Total Harmonic Distortion
Gnd.			
GFCI	Ground-Fault Circuit Interrupter	TSP	Twisted Shielded Pair

GFP	Ground-Fault Protection	TST	Twisted Shielded Triplet
HD	Heavy Duty	TVSS	Transient Voltage Surge Suppressor
HP	Horsepower	UL	Underwriters Laboratories Inc.
IBC	International Building Code	UON	Unless Otherwise Noted
IEEE	The Institute of Electrical and Electronics Engineers	V	Volts
IMC	Intermediate Metallic Conduit	W	Watts
KVA	Kilovolt-Amps	WFC	Watertight Flexible Conduit
KW	Kilo Watt	WG	Wire Guard
KA	Kilo Amps	XFMR	Transformer
LCCF	Lamp Current Crest Factor		

1.3 QUALITY ASSURANCE

- A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section. These shall include, but not be limited to, an electrical supervisor who is a licensed master electrician, a field foreman with a minimum journeyman electrician's license and adequate electricians and helpers.
- B. Without additional cost to the Owner, provide such other labor and materials required to complete the work of this Section in accordance with the requirements of governmental agencies having jurisdiction, regardless of whether such materials and associated labor are called for elsewhere in these Contract Documents.
- C. Electrical subcontractor shall furnish a 100 percent performance bond and a 100 percent payment bond to the Contractor as security for the faithful performance of this Section, as security for the payment of all persons performing labor on the project under this Section and furnishing materials in connection with this Section. The performance bond and payment bond shall be in separate instruments.

1.4 SUBMITTALS

- A. Comply with pertinent provisions of Section 01340.
- B. Product data: Within 30 calendar days after the Contractor has received the Owner's Notice to Proceed, submit:
 - 1. Manufacturer's data sheets for each product listed in Part 2.
 - 2. Manufacturer's recommended installation procedures which, when approved by the Engineer, will become the basis for accepting or rejecting actual installation procedures used on the Work.

C. Layouts:

1. In addition to manufacturer's equipment shop drawings, submit electrical installation working drawings containing the following:
 - a. Concealed and buried conduit layouts, shown on floor plans drawn at not less than 1/4" = 1-ft-0-in scale. The layouts shall include locations of process equipment, motor control centers, transformers, panelboards, control panels and equipment, motors, switches, motor starters, large junction or pull boxes, instruments and other electrical devices connected to concealed or buried conduits.
 - b. Plans shall be drawn on high quality reproducible, media, size 22" by 34" and shall be presented in a neat, professional manner.
 - c. Concrete floors and/or walls containing concealed conduits shall not be poured until conduit layouts are approved.

D. Operational and Maintenance Manual: Upon completion of this portion of the Work and as a condition of its acceptance, provide operation and maintenance manuals in accordance with the provisions of Section 01650 of these Specifications. Include within each manual:

1. Copy of the approved Record Documents for this portion of the Work.
2. Copies of all circuit directories.
3. Copies of all warranties and guaranties.

1.5 PRODUCT HANDLING

- A. Comply with pertinent provisions of Section 01640.

1.6 WARRANTY

- A. Provide standard one (1) year warranty on all labor and materials.
- B. Provide minimum ten (10) year warranty on Surge Protection Devices, incorporating unlimited replacements of suppressor parts if destroyed by transients during the warranty period.
- C. Provide standard five (5) year parts and labor warranty on manual transfer switches.
- D. Comply with Section 01650.

1.7 RULES AND PERMITS

- A. The entire installation shall be in accordance with the latest edition of the NEC, OSHA, and all local codes.

- B. Apply and pay for all permits and inspections required by local or state laws.
- C. Furnish the Owner with certificate of inspection and final approval from all authorities having jurisdiction.
- D. Installers of PVC Coated Conduit shall be certified and be able to present a valid, unexpired installer certification card prior to installation taking place.

1.8 DRAWINGS

- A. The drawings and specifications are complementary to each other and what is called for by one shall be as binding as if called for by both. The drawings are diagrammatic and are to be followed as closely as the construction will permit.
- B. The drawings show the general location of outlets, conduits and circuit arrangement. Because of the small scale of the drawings, it is not possible to indicate all of the detail involved. The Contractor shall carefully investigate the structural and finish conditions affecting all his Work and shall arrange such work accordingly, furnishing such fittings, junction boxes and accessories as may be required to meet such conditions.

1.9 ELECTRICAL SERVICE

- A. From the utility company, establish requirements for transformer pad(s), metering, connections, etc., and make provisions for them; providing and installing all lugs, connectors, grounding, etc., required for a complete installation.
 - 1. Coordinate work with both the electric utility company and the Owner and schedule the installation of the service in accordance with the construction schedule such that there will be no delays in equipment startup and placing the facilities in operation.

1.10 ELECTRICAL OUTAGE

- A. Coordinate all outages with the Owner, 72 hours prior. Schedule all outages such that they will not interfere with normal plant operation and that there will be no delays in equipment startup and placing the facilities in operation.

1.11 SPARE PARTS

- A. Provide the following spare parts to Owner in neatly packaged box marked with contents:
 - 1. Keys: One (1) set of spare panelboard/switchboard keys with lists to Owner.
 - 2. Fuses: One (1) box fuses for each type and size installed on the project.

3. Fuse Puller: One (1) fuse puller to Owner capable of removing all types of fuses installed on job.
4. SPD: One (1) SPD protection module per unit as an on-site spare.
5. Control and Lighting Fixture Lamps: Ten (10) percent of quantity furnished, minimum of one of each type.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Provide only materials that are new, of the type and quality specified. Where Underwriters' Laboratories, Inc. have established standards for such materials, provide only materials bearing the UL label. Materials called for are to be considered as standard that, however, implies no right on the part of the Contractor to substitute other materials and methods without written authority from the Engineer.
- B. Temporary power:
 1. In addition to providing temporary power as described in Section 01500 of these Specifications, provide and pay the costs for installing permanent electrical meter or meters.
 2. When all equipment is in place and connected, and the Engineer determines the project is ready for final checkout, arrange to have the permanent metering installed in the Owner's name. At this point, the Owner will be responsible for all charges.
- C. Where any material or operation is specified by reference to published specifications or standards or the specifications or standards of any other organization; the referenced specification or standard shall be as much a part of this Section as if quoted in full herein.

2.2 RACEWAYS

- A. Applicable Standards:
 1. ANSI C80.1: Rigid Steel Conduits, Zinc-Coated.
 2. ANSI C80.3: Electrical Metallic Tubing, Zinc Coated.
 3. ANSI C80.5: Rigid Aluminum Conduits.
 4. ANSI C80.6: Intermediate Metallic Conduits.
 5. ANSI/NEMA FB1: Fittings and Supports for Conduit and Cable Assemblies.
 6. UL 6: Rigid Steel Conduit – Zinc Coated.
 7. UL 651-2002: Schedule 40 PVC and schedule 80 Rigid PVC Conduit.
 8. UL 514B: Flexible conduit fittings.

9. NEMA RN 1: Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
 10. NEMA FB 1: Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable.
 11. ASTM F512: Polyvinyl Chloride (PVC) Conduit.
 12. ASTM D870: Standard Practice for Testing Water Resistance of Coatings Using Water Immersion.
 13. ASTM D1151: Standard Practice for Effect of Moisture and Temperature on Adhesive Bonds.
 14. FS WW-C 581E: Federal Specification for Rigid Galvanized Steel Conduit.
 15. FS-WW-C-563A: Federal Specification for Electrical Metallic Tubing.
 16. FS-WW-C-540C: Federal Specification for Rigid Aluminum Conduit.
 17. FS WW-C 566: Federal Specification for Flexible Metal Conduit.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Wheatland.
 2. Allied Tube.
 3. Carlon.
 4. Perma-Cote; Division of Robroy.
 5. Ocal.
 6. Plasti-Bond
 7. KorKap
 8. Or Engineer Approved Equal.
- C. Metal Conduits, Tubing, and Fittings
1. Galvanized rigid steel conduit (GRC): Comply with ANSI C80.1 and UL 6.
 2. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit IMC.
 - a. Comply with NEMA RN 1.
 - b. Coating Thickness: 0.040 inch (1 mm), minimum.
 3. Liquid-tight flexible metallic conduit (LFMC): Flexible steel conduit with PVC jacket and complying with UL 360.
 4. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
 5. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.
 6. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.
- D. Nonmetallic Conduits, Tubing, and Fittings

1. Rigid nonmetallic conduit (RNC): Type EPC-80-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
2. Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material. Provide threaded type fittings and form 8 conduit bodies with material to match conduit.
3. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. Conduit/Cable supports – properties:

1. Provide 316 stainless steel supports for all exposed metallic conduit as manufactured by Unistrut or approved equal.
2. Provide fiberglass supports for all exposed non-metallic conduit/cable as manufactured by Aickinstrut or approved equal.
3. Provide one-hole, PVC coated, malleable iron conduit straps with back spacer for all PVC coated rigid galvanized steel conduit.
4. Provide PVC coated beam clamps with uncoated 316 stainless steel nuts and bolts for all PVC coated rigid galvanized steel conduit.
5. Provide stainless steel strain relief and cable grips/supports for power cables. Tie each support of to the hanger support. Provide Type 316 stainless steel clevis hangers, McMaster Carr 3037T666 or equal, with stainless steel rods and Type 316 stainless steel hardware.
6. Provide fiberglass loop hangers, McMaster Carr 451 or equal, with stainless steel rods for all exposed non-metallic conduit/cable.

F. All conduits to conform to the following specifications:

1. Installation under concrete slab: RNC.
2. Exposed outdoor location: PVC-Coated Steel Conduit.
3. Exposed Interior location: GRC.
4. Installation in concrete encased duct banks: RNC.
5. Installation underground exposed to earth: RNC.

2.3 CONDUCTORS

A. Applicable standards:

1. NEMA WC 3: Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
2. NEMA WC 5: Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
3. UL 44 – 2002: Rubber-Insulated Wires and Cables.
4. UL 83 – 1999: Thermoplastic-Insulated Wires and Cables.
5. UL 854 – 2002: Service Entrance Cables.

6. ATSM B496: Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors.
 7. ICEA S-94-649: Concentric Neutral Cables Rated 5-46 kV.
 8. AEIC CS8: Specification for Extruded Dielectric Shielded Power Cables Rated 5 through 46 kV.
 9. RUS Bulletin 50-70: REA Specifications for 15 kV and 25 kV Primary Underground Power Cable.
- B. Conductors: Subject to compliance with requirements, provide products by one of the following:
1. Alpha Wire Company.
 2. Belden Inc.
 3. Cooper Industries, Inc.
 4. Encore Wire Corporation.
 5. General Cable; General Cable Corporation.
 6. Senator Wire & Cable Company.
 7. Southwire Company.
 8. Or Engineer Approved Equal.
- C. Connectors: Subject to compliance with requirements, provide products by one of the following:
1. 3M.
 2. AFC Cable Systems; a part of Atkore International.
 3. Gardner Bender.
 4. Hubbell Power Systems, Inc.
 5. Ideal Industries, Inc.
 6. NSi Industries LLC.
 7. O-Z/Gedney; a brand of Emerson Industrial Automation.
 8. Or Engineer Approved Equal.
- D. 600 V Conductors
1. Copper Conductors: Comply with NEMA WC 70/ICEA S-95-658.
 2. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Type THHN/THWN-2 and Type XHHW-2.
 3. Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.4 GROUNDING AND BONDING

- A. Applicable standards:
1. UL 467-1998: Grounding and Bonding Equipment.
 2. NFPA 70: National Electrical Code.

3. ANSI/IEEE 32: Requirements, Terms and Test Procedures for Neutral Grounding Devices.
 4. IEEE 80: Guide for Safety in Substation Grounding.
 5. IEEE 81: Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
 6. NETA ATS: Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems (International Electrical Testing Associates).
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Burndy; Part of Hubbell Electrical Systems.
 2. ERICO International Corporation.
 3. Galvan Industries, Inc.; Electrical Products Division, LLC.
 4. O-Z/Gedney; a brand of Emerson Industrial Automation.
 5. Or Engineer Approved Equal.
- C. Conductors
1. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
 2. Bare Copper Conductors: Stranded Conductors: ASTM B 8.
 3. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.
- D. Connectors
1. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
 2. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.
 3. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
 4. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
- E. Grounding Electrodes
1. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet.
- F. Ground Enhancing Material
1. Maintains constant resistance for the life of the system

2. Does not require the continuous presence of water to maintain its conductivity.
3. Non-corrosive
4. Complies with or exceeds IEC 62561-7
5. Complies to the U.S. Environmental Protection Agency (EPA)
6. Resistivity: <2 Ω -cm for powder <20 Ω -cm for mixed and cured material
7. Flexural Strength: 300-450 psi
8. Compressive Strength: 100-200 psi after 672 hours curing time

G. Ground Access Wells:

1. Provide 12"x12"x12" polymer concrete ground access well where indicated on plans.
2. Provide engraved cover with "ground" indicator.
3. Rated for a minimum of 20,000 lbs.
4. Provide Harger GAW series or approved equal.

2.5 SURGE SUPPRESSION

A. Applicable standards:

1. UL 1449 4th Edition - Standard for Safety of Surge Protection Devices.
2. ANSI/IEEE C62.41.1-2002 - IEEE Guide on the Surge Environment in Low-Voltage AC Power Circuits
3. ANSI/IEEE C62.41.2 – IEEE Recommended Practice on Characterization of Surges in Low Voltage AC Power Circuits.
4. IEEE C62.45-2002 - IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits.
5. UL 67 - Panelboards (when mounted in panelboards).
6. UL 891 - Dead-Front Switchboards (when mounted in switchboards).
7. NEMA LS1 - National Electrical Manufacturer's Association – 1992, R2000.
8. MIL STD. 220C - Test Methods of Insertion Loss Measurement.

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

1. ASCO Power Technologies, Inc.
2. APC by Schneider Electric
3. Cutler Hammer by Eaton.
4. Current Technology by Thomas and Betts.
5. Or Engineer Approved Equal.

C. Surge Suppression Device (SPD):

1. Manufacturer's published UL 1449 Third Edition test results shall reflect SPD connected lead length of 6" or greater.

2. Provide SPD devices with a minimum EMI/RFI filtering of -50dB at 100 kHz using MIL-STD-220A methodology.
3. Provide a SPD unit with a short circuit current rating (SCCR) clearly marked and install at a point on the system where the available fault current is not in excess of that rating.
4. Provide dedicated circuit breaker/disconnect for the SPD.
5. Provide SPD with one set of NO/NC dry contacts.
6. Provide SPD with protection-indicating LED's that are visible without opening enclosure.
7. Provide NEMA 4X 316 stainless steel enclosures for all interior process area and exterior installations. Provide NEMA 12 (stainless steel) in all other installations.
8. Provide a Type 2 SPD with 20kA I-nominal (In) rating.
9. Provide SPD that meets or exceeds the following criteria:
 - a. Maximum UL 1449 Voltage Protection Ratings (VPR) and Maximum Continuous Operating Voltage (MCOV):

System Voltage	L-N	L-G	N-G	L-L	MCOV
120/240V 1Ø Split Phase	700	700	700	1200	150
240/120V 3Ø High Leg	700/1200	700/1200	700	700/1200	150/320
208/120V 3Ø	700	700	700	1200	150
480/277V 3Ø	1200	1200	1200	2000	320

- b. Minimum Surge Capacity and modes of protection:

SPD Location	Modular Parallel Protection	Modes of Protection	RFI Filtering	Surge Capacity Per Phase
Service Entrance \geq 800A	Yes	L-N, N-G, L-G	Yes	300kA
Service Entrance $>$ 200A, $<$ 800A	Yes	L-N, N-G, L-G	Yes	200kA
Service Entrance \leq 200A	No	L-N, N-G, L-G	No	100kA
Distribution Panel \geq 800A	Yes	L-N, N-G, L-G	Yes	200kA
Distribution Panel $>$ 400A, $<$ 800A	Yes	L-N, N-G, L-G	Yes	150kA
Distribution Panel \leq 400A	No	L-N, N-G, L-G	No	100kA

SPD Location	Modular Parallel Protection	Modes of Protection	RFI Filtering	Surge Capacity Per Phase
Motor Control Center \geq 2000A	Yes	L-N, N-G, L-G	Yes	300kA
Motor Control Center $>$ 600A, $<$ 2000A	Yes	L-N, N-G, L-G	Yes	200kA
Motor Control Center \leq 600A	Yes	L-N, N-G, L-G	Yes	150kA
Branch Circuit Panels $>$ 200A	No	L-N, N-G, L-G	No	150kA
Branch Circuit Panels \leq 200A	No	L-N, N-G, L-G	No	100kA

2.6 OUTLET BOXES

A. Applicable standards:

1. ANSI/NEMA OS 1: Sheet-steel Outlet Boxes, Device Boxes, Covers and Box Supports.
2. ANSI/NEMA OS 2: Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports.
3. NEMA 250: Enclosures for Electrical Equipment (1000 Volts Maximum).
4. NEMA FB 1: Type FD, Cast Ferroalloy Boxes.
5. UL 508: UL Standard for Safety Industrial Control Equipment.

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

1. O.Z./Gedney Company.
2. Crouse-Hinds Electrical Construction Materials.
3. Appleton Electric Company.
4. Or Engineer Approved Equal.

C. Boxes

1. In NEMA and NEMA 12 areas, provide standard, sheet-metal, outlet and junction boxes constructed of code-gauge, galvanized sheet steel. Size each box as required by the NEC.
2. Provide boxes and covers for polyvinylchloride-coated steel conduit made of fiberglass reinforced resin. Boxes shall have hubs with extruded sleeves extending beyond the hub in the same manner as specified for conduit couplings. Provide cover screws of stainless steel.

3. Provide polyvinylchloride boxes for use as junction boxes and provide high impact strength fiberglass-reinforced polyester boxes for use as device boxes, pull boxes, and terminal boxes for use with polyvinylchloride conduit. Size each box as required by the NEC.

D. Fittings

1. Provide cast-iron fittings of malleable iron or a mixture of gray iron and cast steel.
2. Provide suitable expansion fittings where conduits cross expansion joints. Equip these fittings with grounding straps, clamps, and copper bonding jumpers.

2.7 UNDERGROUND DUCTS

A. Applicable standards:

1. ANSI/SCTE 77: Specification for Underground Enclosure Integrity.
2. ASTM C1028: Standard Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method.
3. ASTM C478-03a" Standard Specification for Pre-cast Reinforced Concrete Manhole Sections.
4. ASTM A615: Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
5. ASTM C857-07: Practice of Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
6. ASTM 858-07: Specifications for Underground Precast Concrete Utility Structures.

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

1. Quazite by Hubbell
2. Oldcastle Precast
3. Associated Concrete Products
4. Or Engineer Approved Equal.

C. Handholes:

1. Provide handholes a minimum size of 24" x 36" x 24" and larger sizes as required by per NEC.
2. Provide traffic rated enclosures with knockouts as indicated on plans and cover tested to a minimum of 32,000 psi. Provide cover engraved with "Electric" or "Communications" as directed on plans.
3. Provide traffic rated enclosures equal to Fibercrete FHR series or Engineer approved equal.

4. Provide enclosures with divider, pulling eyes, cable racks and extension sleeves as applicable.
 5. Provide enclosures equal to Quazite PG series with HA type cover.
- D. Conduit Spacers: Furnish conduit spacers made of plastic to maintain spacing between conduits.
- E. Concrete: Minimum compressive strength, 3,000 psi.
- F. Handhole Frames and Covers:
1. Heavy duty gray cast iron.
 2. Conform to details indicated on the drawings and as specified.
 3. Provide machine-finished seat.
 4. Mark "ELECTRICAL" on cover of manhole

2.8 WIRING DEVICES

- A. Applicable standards:
1. FS W-C-596: Electrical Power Connector, Plug, Receptacle, and Cable Outlet.
 2. FS W-S-896: Switch, Toggle.
 3. NEMA WD 1: General Purpose Wiring Devices.
 4. NEMA WD 2: Semiconductor Dimmers for Incandescent Lamps.
 5. NEMA WD 5: Specific Purpose Wiring Devices.
 6. UL 943: Standard for Ground Fault Circuit Interrupters.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Hubbell.
 2. Pass and Seymour.
 3. ABB – General Electric.
 4. TayMac.
 5. Lutron.
 6. Leviton.
 7. Or Engineer Approved Equal.
- C. Switches:
1. Switches for lighting circuits and motor loads under 1/2 HP conforming to NEMA WD; FS W-S-896; AC-general use snap switch with toggle handle, rated 20 amperes and 120-277VAC.
 2. Gray handle.
 3. For exterior applications, provide cast box and weatherproof actuating lever toggle switch cover.

- D. GFCI Receptacles:
1. GFCI Convenience Receptacles, 125 V, 20 A.
 2. Straight blade, feed-through type.
 3. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.
 4. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.
- E. Wall Plates:
1. Provide continuous-use rated exterior device cover. Provide cover constructed entirely of UV stabilized high impact polycarbonate material with gasket, stainless steel mounting screws and UL listed for wet location continuous-use. Provide cover equal to TayMac Specification Grade series.
 2. Design plates to fit the device or devices on which they are used.

2.9 ENCLOSURES

- A. Description: Flush or surface-mounted cabinets. NEMA 250, Type 1, unless otherwise indicated to meet environmental conditions at installed location. Wet or Damp Indoor and Outdoor Locations: NEMA 250, Type 4X, stainless steel.

2.10 PANELBOARDS

- A. Applicable standards:
1. FS W-C-375: Circuit Breakers, Molded Case, Branch Circuit and Service.
 2. FS W-F-870: Fuse Holders (for Plug and Enclosed Fuses).
 3. FS W-F-115: Power Distribution Panel.
 4. FS W-S-865: Enclosed Knife Switch.
 5. NEMA AB 1: Molded Case Circuit Breakers.
 6. NEMA PB 1: Panelboards.
 7. NEMA PB 1.1: Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
 8. NEMA PB 1.2: Application Guide for Ground-fault Protective Devices for Equipment.
 9. UL 67: Panelboards.
- B. Acceptable manufacturers:
1. Square D by Schneider Electric
 2. Cutler-Hammer by Eaton
 3. Siemens Industry, Inc.

4. Or Engineer Approved Equal.

C. Power Panelboards:

1. Panelboards: NEMA PB 1; distribution type.
2. Enclosure: NEMA PB 1, Type 12, unless shown otherwise on the Drawings.
3. Panelboard mounting as shown on the Drawings.
4. Provide cabinet front with concealed trim clamps, and hinged door with flush lock. Finish in manufacturer's standard gray enamel.
5. Provide panelboards with tin plated, copper bus, ratings as scheduled.
6. Provide copper ground bus in all panelboards. Minimum integrated short circuit rating: As shown in panel schedules.
7. Molded case circuit breakers: NEMA AB 1; provide bolt-in-type circuit breakers with integral thermal and instantaneous magnetic trip in each pole.
8. Molded case circuit breakers with current limiters: AB 1; provide circuit breakers with replaceable current limiting elements, in addition to integral thermal and instantaneous magnetic trip in each pole.
9. Provide panelboards with typed directory as shown on panel schedules.
10. Provide panelboards keyed alike.

2.11 MISCELLANEOUS MATERIALS

- A. Provide support framing, channel and associated accessories of 316 stainless steel conforming to the Drawings and to Sections 05990 of these specifications, except in areas containing chemicals, whereby fiberglass reinforced plastic only shall be utilized.
- B. Provide and install equipment racks for panels as shown on the drawings and as described in the specifications, with the following as a minimum:
1. Provide cross members consisting of two (2) horizontal pieces of pre-drilled 1-1/2" x 1-1/2" mounting channel, manufactured by Kindorff or Engineer approved equal.
 2. Attach all struts with spring-loaded nuts and associated hardware provided by manufacturer of strut and specifically designed for this purpose.
 3. Use 316 stainless steel stud nuts, manufactured by Kindorff or Engineer approved equal.
 4. Support the mounting channel "cross bars" vertically by C-channels, 3" x 2" x 8'.
 5. Mount channels a maximum of 24" apart, center-to-center, quantity as required to accommodate equipment.
 6. Provide a foundation buried 36" underground and secured with 3000 PSI concrete pad, sized as shown on plans with a minimum of 36" clear walking space in front of control panels and 12" on sides and rear of panel.

7. Provide $\frac{3}{4}$ " chamfer on all concrete edges.
- C. Provide 316 stainless steel (bolts, nuts, washers, U-bolts, anchors, threaded rods, etc.) attachment hardware.

2.12 ELECTRICAL SYSTEM STUDIES

- A. Provide a short circuit, protective device coordination and arc-flash study for the electrical distribution system constructed under this contract. The study shall consider the electrical utility system upstream protective devices down to the 480Y/277V transformer secondary. The study shall include calculations used to verify the short circuit ratings of the electrical distribution equipment to be provided under this contract and to identify the required settings of associated protective devices.
- B. Provide a report summarizing the coordination study including: one-line of system, relay and breaker setting tabulation, relay, circuit breaker, and fuse protective device coordination and short circuit calculation, all prepared by an independent specialty firm. Device calibration and settings are to be based on the results of this coordination study.
- C. Short Circuit Study
1. Perform a short circuit study in accordance with ANSI Standard C37.010 to verify the adequacy and correct application of circuit protective devices and other electrical system components.
 2. The study shall address the case when the system is being powered from the utility source as well as from the on-site generating facilities. Minimum and maximum possible fault conditions shall be covered in the study.
 3. Include the fault contribution of all motors. Horsepower shown in the Contract Documents may be used to calculate fault contribution of motors. In the short circuit study VFDs shall be replaced by conductors of the same size as the branch circuit conductors.
 4. Calculate short-circuit momentary duties and interrupting duties on the basis of an assumed bolted 3-phase short circuit at each bus. The short circuit tabulations shall include X/R ratios, asymmetry factors, kVA and symmetrical fault-current. Where ground fault protection is specified, provide a ground fault current study for the same system areas, including the associated zero sequence impedance diagram. Include in tabulation form, fault impedance, X/R ratios, asymmetry factors, motor contribution, short circuit kVA, and symmetrical and asymmetrical fault currents.
 5. The studies shall include representation of the site power system, the base quantities selected, impedance source data, calculation methods and tabulations, one-line diagrams, conclusions and recommendations.

D. Protective Device Coordination Study

1. Provide a protective device time current coordination study with coordination plots of current limiting devices, plus tabulated data, including ratings and settings selected. In the study, balance shall be achieved between the competing objectives of protection and continuity of service (with emphasis on continuity of service) for the system specified, taking into account the basic factors of sensitivity, selectivity and speed.
2. Provide separate plots for utility and generator operation as applicable. Show maximum and minimum fault values in each case. Multiple power sources shown in one plot is not acceptable.
3. Each primary protective device required for a delta-to-wye-connected transformer shall be selected so the characteristic or operating band is within the transformer parameters, which, where feasible, shall include a parameter equivalent to 58 percent of the ANSI withstand point to afford protection for secondary line-to-ground faults. Separate low voltage circuit breakers from each other and the associated primary protective device, by a 16 percent current margin for coordination and protection in the event of line-to-line faults. Separate protective relays by a 0.4 second time margin when the maximum 3 phase fault flows to assure proper selectivity. The protective device characteristics or operating bands shall be terminated to reflect the actual symmetrical and asymmetrical fault-currents sensed by the device. Provide the coordination plots for 3 phase and phase-to-ground faults on a system basis. Include all devices down to largest branch circuit feeder circuit breaker. Include all adjustable setting ground fault protective devices.
4. Identify discrepancies in the conclusions and recommendations of the report. Upon resolution of discrepancies and recommendation, update all associated analyses and revise the affected studies.
5. The coordination plots shall graphically indicate the coordination proposed for the several systems centered on full scale log forms. The coordination plots shall include complete titles, representative one-line diagrams and legends, associated upstream power system relays, fuse or system characteristics, significant motor starting characteristics, significant generator characteristics, complete parameters for power, and substation transformers, complete operating bands for low voltage circuit breaker trip devices, fuses, and the associated system load protective devices. The coordination plots shall define the types of protective devices selected, together with the proposed coil taps, time-dial settings and pick-up settings required. The short-time region shall indicate the relay instantaneous elements, the magnetizing inrush, and ANSI transformer damage curves, the low voltage circuit breaker and instantaneous trip devices, fuse manufacturing tolerance bands, and significant symmetrical and asymmetrical fault-currents.

6. The thermal limit of all feeder cables to each bus and large motors, where applicable in the study, shall be shown.
7. No more than six devices shall be shown on one coordination plot. Of these six curves, two (the largest upstream device and the smallest downstream device) shall repeat curves shown on other coordination plots in order to provide cross reference. Give each unique protective device curve in the study a study-unique number or letter identifier to permit cross reference between plots. Do not use identifier letters or numbers more than once.
8. Each primary protective device required for delta-wye connected transformer shall be selected so that the characteristic or operating band is within the transformer parameters, which, where feasible, shall include a parameter equivalent to 58 percent of the ANSI withstand point to assure protection for secondary line-to-ground faults.
9. Include a detailed description of each protective device identifying its type, function, manufacturer, and time-current characteristics. Tabulate recommended device tap, time dial, pickup, instantaneous, and time delay settings. Include C.T. ratio, burden and all other calculations required for the determination of settings.

E. Arc Flash Hazard Analysis

1. Perform arc flash hazard analysis for the following items:
 - a. Panelboards
 - b. Control panels with voltage over 50 Volts
 - c. Motor control centers
 - d. Transformers that have auxiliary electrical devices operating at over 50 Volts
 - e. Manual transfer switches
2. Methods of performing analysis:
 - a. Use NFPA 70E article 130 tables if the short circuit study shows that the condition for those tables are met.
 - b. Otherwise use IEEE 1584 calculations.
 - 1) If the conditions fall within the IEEE 1584 parameters use the IEEE 1584 calculations based on actual OCPD curves and settings.
 - 2) If the conditions do not fall within the 1584 parameters, use the Lee method.
3. Label each item for which the calculations were performed with the following information:
 - a. Limited approach boundary
 - b. Information required by NFPA 70E, 130.2(D)(2).
 - c. Restricted approach boundary

- d. Personal protective equipment required within restricted approach boundary
- e. Flash protection boundary
- f. Personal protective equipment required within flash protection boundary
- g. Prohibited approach boundary

2.13 IDENTIFICATION

- A. Mark all 480-volt equipment with red laminated plastic nameplates having one-half inch (1/2") engraved lettering, reading "DANGER 480-VOLTS". Attach plate to equipment with stainless steel screws.
- B. Mark conductors within panelboards with self-sticking label bearing the number corresponding to the circuit number on the drawings. Connect these conductors to corresponding breaker in panel. Mark circuit numbers in outlet boxes only where color-coding is repeated by having two or more conductors of the same color.
- C. Mark equipment, switchboards, panelboards, cabinets, transformers, control devices, starters, switches, etc.
- D. Labels shall be created by means of black phenolic material having engraved Micarta letters with white core having 1/4" engraved lettering.
- E. Provide designations as indicated on the drawings to include:
 - 1. Name of the equipment or equipment that is being served,
 - 2. Power source and circuit of origin along with room location
 - 3. Voltage and number of phases.
- F. Attach plates to equipment with stainless steel screws.
- G. Mark all junction boxes with the voltages contained internal to it. If multiple power sources are internal to the junction boxes, it shall be labelled "Contains Multiple Power Sources"
- H. Panelboards shall contain typed and laminated panel schedules indicating circuit numbers and loads
- I. Arc Flash Warning Labels
 - 1. Labels: 3.5-by-5-inch (76-by-127-mm) thermal transfer label of high-adhesion polyester for each work location included in the analysis.
 - 2. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

- a. Location designation.
 - b. Nominal voltage.
 - c. Flash protection boundary.
 - d. Hazard risk category.
 - e. Incident energy.
 - f. Working distance.
 - g. Engineering report number, revision number, and issue date.
3. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 SURFACE CONDITIONS

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

3.2 PREPARATION

- A. Coordination:
 1. Coordinate as necessary with other trades to assure proper and adequate provision in the work of those trades for interface with the work of this Section.
 2. Coordinate the installation of electrical items with the schedule for work of other trades to prevent unnecessary delays in the total Work.
 3. Where lighting fixtures and other electrical items are shown in conflict with locations of structural members and mechanical or other equipment, provide required supports and wiring to clear the encroachment.
- B. Data indicated on the Drawings and in these Specifications are as exact as could be secured, but their absolute accuracy is not warranted. The exact locations, distances, levels, and other conditions will be governed by actual construction and the Drawings and Specifications should be used only for guidance in such regard.
- C. Where outlets are not specifically located on the Drawings, locate as determined in the field by the Engineer. Where outlets are installed without such specific direction, relocate as directed by the Engineer and at no additional cost to the Owner.
- D. Verify all measurements at the building. No extra compensation will be allowed because of differences between work shown on the Drawings and actual measurements at the site of construction.

- E. Branch circuit wiring and arrangement of home runs have been designed for maximum economy consistent with adequate sizing for voltage drops and other considerations. Install the wiring with circuits arranged exactly as shown on the Drawings, except as otherwise approved in advance by the Engineer.

3.3 ELECTRICAL SERVICE

- A. Verify location of utility company secondary delivery point and report any discrepancies to the Engineer immediately.

3.4 TRENCHING AND BACKFILLING

- A. Perform trenching and backfilling associated with the work of this Section in strict accordance with the provisions of Section 02221.

3.5 RACEWAYS AND FITTINGS

- A. When PVC coated conduit systems are utilized, the raceway manufacturer prior to installation shall certify the Contractor. Submit certification to the Engineer in writing.
- B. When PVC coated conduit systems are utilized, provide inspection and certification of the complete raceway installation in writing by an authorized representative of the PVC coated materials supplier.
 - 1. During the construction process, at regular intervals, and prior to any raceway being covered, the representative shall inspect the system until it is confirmed that it meets the manufacturer's intended requirements.
 - 2. Remove and reinstall any portion of the conduit installation that does not meet the intended installation methods at no additional cost to the Owner.
- C. Provide certification to insure that all PVC overlapping connections, conduit threading, thread coating, sealing, etc., has been performed in accordance with manufacturer's recommended procedures.
- D. Apply cold galvanizing compound to all field-cut threads prior to installation.
- E. In general, follow the raceway installation layout shown on the plans, however, this layout is diagrammatic only, and where changes are necessary due to structural conditions, other apparatus or other causes, make such changes without any additional cost to the Owner.
- F. Cut all conduits square using a saw or pipe cutter and de-burr cut ends.
- G. Install the conduit to the shoulder of fittings and couplings and fastened securely.

- H. Use conduit hubs, or sealing locknuts, for fastening conduit to cast boxes and for fastening conduit to sheet metal boxes in damp or wet locations.
- I. No more than the equivalent of three 90-degree bends may be installed between boxes.
- J. Use conduit bodies to make sharp changes in direction, as around beams.
- K. Use hydraulic one-shot conduit bender or factory elbows for bends in conduit larger than 2" size.
- L. Avoid Moisture traps where possible; where moisture traps are unavoidable, there must be a junction box with drain fitting provided at the conduit low point. Use suitable conduit caps to protect installed conduit against entrance of dirt, concrete, plaster, mortar, and moisture.
- M. Size all conduits for conductor type installed with 3/4" being the minimum size conduit allowed.
- N. Arrange conduit to maintain headroom and present a neat appearance.
- O. Route any exposed conduit and conduit above accessible ceilings parallel and perpendicular to walls and adjacent piping.
- P. Provide at all times a minimum of 6" clearance between conduit and piping and a 12" clearance between conduit and heat sources such as flues, steam pipes, and heating appliances.
- Q. Arrange all conduit supports to prevent distortion of alignment by conductor pulling operations.
- R. Fasten conduits above finished ceilings using straps, lay-in adjustable hangers, clevis hangers or bolted split stamped hangers.
 - 1. Do not fasten conduit with wire or perforated pipe straps. All wire that was used for temporary conduit support during construction must be removed before conductors are pulled.
 - 2. All conduits must be supported at a maximum distance of 5' on centers.
- S. Group conduits in parallel runs where practical using a conduit rack.
- T. Make all underground conduit joints watertight by applying manufacturer's recommended thread compound. Thread compound must be conductive and be compatible with conduit and conductor-jacket material.

- U. Provide suitable pull string or #12 AWG insulated conductor in empty conduit, except sleeves and nipples.
- V. Maintain minimum 12" clearance between all conduits containing signal circuits and conduits containing power circuits.
- W. Install expansion-deflection joints where conduit crosses building expansion or seismic joints.
- X. Where conduit penetrates fire-rated walls and floors, the opening around the conduit must be sealed with UL listed foamed silicone elastomer compound.
- Y. Install exposed raceways either parallel or perpendicular to building walls.
- Z. Install raceways exposed on walls or free standing perpendicular to the floor.
- AA. Install exposed raceways on channel so as to provide a minimum spacing of 1/2" between raceway and the surface to which it is mounted.
- BB. Bends:
 - 1. Where emerging from walls, ceilings, floor or concrete slabs, all conduit bends shall be made entirely within the structure (i.e.: the conduit shall emerge perpendicular to the surface and the bend shall be covered).
 - 2. Make all 90-degree conduit turns with factory-bent, rigid galvanized steel, long radius elbows.
 - 3. Utilize rigid galvanized steel, long radius elbows on all 90 degree conduit bends of 2" and larger.
- CC. Install no metal conduit in contact with the earth or concrete slab unless protected with two coats of bitumastic coating.
- DD. Provide necessary sleeves and chases where conduits pass through floors and walls, and provide other necessary openings and spaces, arranging for in proper time to prevent unnecessary cutting in connection with the Work.
- EE. Perform cutting and patching in accordance with the provisions for the original Work.
- FF. Refer to Section 02221 for minimum cover of underground conduits.
- GG. Sealing Conduit:
 - 1. Install watertight conduit hubs on all conduits terminating in the top or sides of NEMA 3R, 4 or 4X enclosures.
 - 2. Use a sealing locknut having an integral gasket on conduits terminating in the bottom of NEMA 3R, 4 or 4X enclosures.

3. Seal all conduits terminating in NEMA 3R, 4 or 4X enclosures with duct seal.
 4. Seal watertight all conduits terminating in NEMA 6 or watertight rated enclosures.
 5. Install sealing compound and fiber, per manufacturer's recommendation, in hazardous location conduit sealing fittings. Tighten plugs per manufacturer's recommended torque.
- HH. Make motor lead connections and connections to other electrical equipment subject to vibration, or where indicated with flexible weatherproof type steel core conduit with wrapping and cover, factory assembled.
- II. Conduit installations in hazardous locations as defined by Article 500 of the NEC must conform to the special requirements of Articles 501, 502, and 503 of the NEC.
- JJ. Chapter 9 of the NEC shall apply unless larger raceways are specified.
- KK. Ensure all threads are fully installed into fittings, boxes, enclosures and equipment per NEC and UL listing requirements to provide mechanical integrity, grounding and sealing. Provide fittings and adapters to ensure full length of conduit or conduit fitting threads are installed per code and listing requirements.
- LL. Liquidtight flexible metal conduit shall be supported and securely fastened within 12 inches of each box, cabinet, conduit body or other conduit body termination and shall be supported and secured at intervals not to exceed 4-1/2 feet. Flexible metal conduit shall not exceed 6 feet in length except for luminaire connections as allowed per the NEC.
- MM. Provide plastic threaded type bushings for all conduits terminated in enclosures.

3.6 CONDUCTORS

- A. 600 V Applications
1. Service Entrance: Type XHHW-2, single conductors in raceway.
 2. Exposed Feeders: Type XHHW-2, single conductors in raceway.
 3. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway.
 4. Exposed Branch Circuits, Including in Crawlspace: Type THHN/THWN-2, single conductors in raceway.
 5. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.
- B. Installation
1. Install no conductor smaller than #12 AWG unless otherwise indicated.

2. Provide copper conductors.
3. Provide conductors as shown on the plans or as specified herein.
4. Provide continuous wiring from outlet to outlet, identified by color and marked with size, grade and manufacturer.
5. Provide continuous wiring without joints, through pull boxes.
6. Provide minimum of #10 AWG conductors on branch circuits, which exceed 100' at 120 volts and 200' at 277 volts from panel to load center.
7. Terminate #14 AWG stranded conductors where indicated for control, using insulated compression-type spade lugs.
8. Terminate #12 AWG stranded conductors using insulated compression-type spade lugs.
9. Install an equal number of conductors for each phase of a circuit in the same raceway or cable.
10. The conductor lengths for parallel circuits must be made equal.
11. Neatly train and lace all wiring inside boxes, equipment, and panel boards.
12. Connect circuits sharing a common neutral to different phases regardless of the numbering.
13. Provide phase, neutral, and ground conductors as required to accommodate metering installed. Any additional conductors required for meter to function properly shall be installed at the Contractor's expense.

3.7 GROUNDING AND BONDING

A. Applications

1. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
2. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 4/0 AWG minimum. Bury at least 24 inches below grade. Bury 12 inches above duct bank when indicated as part of duct-bank installation.
3. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
4. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - a. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
 - b. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.
5. Conductor Terminations and Connections
 - a. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.

- b. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 - c. Connections to Ground Rods at Test Wells: Bolted connectors.
 - d. Connections to Structural Steel: Welded connectors.
6. Ground Enhancement Material
- a. Provide for all grounding installed below grade.
 - b. Provide a minimum of 3" diameter coverage.
 - c. Follow manufacturer's instructions for handling, storage, and installation.

B. Installation

1. Ground and bond the electrical system and motors in accordance with Article 250 of the NEC.
2. Install electric bond around panels, cabinets, pull boxes, enclosures, etc., to incoming and outgoing sub-feed raceways by use of grounding type bushings.
3. Install rod electrodes at locations indicated. Install additional rod electrodes as required to achieve specified resistance to ground.
4. Provide grounding electrode conductor(s) and connect as shown on drawings.
5. Bond together metal siding not attached to grounded structure, bond to ground.
6. Provide separate, insulated, green equipment grounding conductor within each feeder and branch circuit raceway. Terminate each end on suitable lug, bus, or bushing.
7. Provide grounding type bushings for conduits 1" or larger and bond to ground bar or lug of enclosure.
8. Bond neutral and ground at service entrance only.
9. Provide exothermic-type weld grounding connections that are buried or otherwise normally inaccessible and excepting specifically those connections for which access is required for periodic testing.
10. Make each grounding connection strictly in accordance with the manufacturer's written instructions. Failure to follow manufacturer's written instructions shall result in immediate rejection.
11. Welds which have "puffed up" or which show convex surfaces, indicating improper cleaning, are not acceptable. Provide grounding connection devices compatible with the conductor(s) and/or rods being joined.
12. Maximum acceptable resistance to earth ground is 25 Ohms. Provide testing of the service entrance system ground and verify the resistance to earth ground is within the specified requirements. If the existing service entrance ground does not meet the specified requirements, install additional rod electrodes as required to achieve specified resistance to ground.

13. Interface with lightning protection system where applicable.

C. Grounding Handholes

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

3.8 SURGE SUPPRESSION

A. Factory Installed:

1. Install SPD on the load side of the main circuit breaker.
2. Provide circuit breaker disconnect for SPD as shown on plans.
3. Install SPD in accordance with manufacturer instructions.
4. Minimum lead length 6”.

B. Field Installed:

1. Connect SPD ground to service entrance grounding electrode conductor or to equipment grounding conductor if SPD located downstream of service entrance equipment. Confirm SPD installed per manufacturer's recommendation.
2. Install SPD on the load side of the main circuit breaker.
3. Install SPD in accordance with manufacturer instructions.
4. Maximum lead length 12”.

3.9 OUTLET BOXES

- A. Do not install boxes back-to-back in walls. Install the boxes at a minimum of 6” apart except in acoustic-rated walls with a minimum separation of 12”.
- B. Locate boxes in masonry walls such that only the cutting of the masonry unit corner is required. Coordinate masonry cutting such that neat openings for the boxes can be achieved.
- C. Provide knockout closures for unused openings.
- D. Support boxes independently of the conduits.

- E. Use multiple gang boxes where more than one device is mounted together; do not use sectional boxes. Provide barriers to separate wiring of different voltage systems.
- F. Install boxes in the walls without damaging wall insulation.
- G. Install outlets to locate luminaires as shown on plans. In inaccessible ceiling areas, position outlets and junction boxes within 6" of recessed luminaires, to be accessible through luminaire ceiling opening.
- H. Provide recessed outlet boxes in finished areas; secure boxes to interior wall and partition studs, accurately positioning to allow for surface finish thickness.
- I. Use stamped steel stud bridges for flush outlets in hollow stud wall, and adjustable steel channel fasteners for flush ceiling outlet boxes.
- J. Align wall mounted outlet boxes for switches, thermostats, and similar devices.
- K. Provide cast outlet boxes in locations (exposed to the weather) and indoor wet locations.
- L. Size all boxes in strict accordance with Article No. 370 of the NEC, except that no box will be less than the minimum specified.
- M. Check the location of all outlets to see that the outlets will clear any new or existing wall fixture, shelving, work tables, sinks, bulletin boards, etc. and the outlet will fit the area intended.
- N. Set floor boxes level and flush with finish flooring material. Use cast iron floor boxes for installations in slab on grade.
- O. Locate pull and junction boxes above accessible ceilings or in unfinished areas. Support pull and junction boxes independently of conduit.
- P. Install underground boxes as shown on drawings with top of box approximately 2" above finished grade. Install bottom of box over 12" of gravel to allow for adequate drainage.

3.10 UNDERGROUND DUCTS

- A. Place a 6-inch crushed-stone base under each handhole.
- B. Install tops of manhole and handhole covers in unpaved areas approximately 1/2-inch above finished grade, and in paved areas install flush with finished surface of paving.

- C. Install two cable pulling irons in wall opposite each ductbank entrance into manhole, one 6 inch above floor and one 6 inch below the roof of manhole. Where indicated on drawings, install additional features such as openings in manhole walls for future conduit entrances.

3.11 WIRING DEVICES

- A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.
- B. Install wall switches at 48" above the floor level and 6" from edge of door jam on strike side, unless otherwise noted on Drawings.
- C. Install wall switches with the OFF position down.
- D. Install convenience receptacles at 18" above the floor level or 6" above counter or backsplash.
- E. Install convenience receptacles with the grounding pole on top.
- F. Install all specific-use receptacles at heights shown on Contract Drawings.
- G. Install decorative plates on switch, receptacle, and blank outlets in finished areas using jumbo size plates for outlets installed in masonry walls.
- H. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface-mounted outlets.
- I. Install devices and wall plates flush and level.

3.12 IDENTIFICATION

- A. Provide color-coding for #12 and #10 conductors as follows:

	277/480-Volt	120/208(240)-Volt
Phase "A"	Brown	Black
Phase "B"	Orange	Red
Phase "C"	Yellow	Blue
Neutral	White with Tracer	White
Ground	Green	Green

- B. Mark all conductors #8 and larger and all feeders with plastic tape to match the above color-coding.
- C. Provide primary cables with phase code as directed by the Engineer.

3.13 CONNECTIONS AND TERMINATIONS IN 600V CONDUCTORS

- A. Provide final connections and/or terminations for all wiring indicated on the electrical drawings and in this division of the specifications. Equipment supplied under other divisions of the specifications that require electrical connections under this division shall be provided with Engineer approved wiring and termination diagrams.
- B. General
 - 1. For #8 AWG, use solderless pressure connectors with insulating covers for copper wire splices and taps. Use insulated spring wire connectors with plastic caps for #10 AWG and smaller.
 - 2. Use insulated, mechanical connectors for copper wire splices and taps, #6AWG and larger. Tape connectors with electrical tape to prevent moisture infiltration.
 - 3. Where connections are located in handholes use insulated submersible type.
 - 4. Thoroughly clean wires before installing lugs and connectors.
 - 5. Terminate spare conductors with electrical tape.
 - 6. Splices are prohibited.

3.14 CONDUIT SUPPORTS

- A. Seal all ends of non-metallic conduit support with manufacturer's recommended sealer.
- B. Provide UL listed vinyl end caps for all ends of strut-type metallic conduit supports.
- C. Provide all miscellaneous materials and supports as required by the NEC and these specifications to provide support for conduits, raceways, boxes, fittings and equipment.

3.15 POWER EQUIPMENT

- A. Provide power and control wiring for motor starters and safety switches as shown on the Drawings.
- B. Connections to miscellaneous building equipment:
 - 1. Wire to, and connect to, all items of building equipment not specifically described but to which electrical power is required.
 - 2. Coordinate as necessary with other trades and suppliers to verify types, numbers, and locations of equipment.

3.16 MOUNTING OF SWITCHGEAR, CONTROL PANELS AND ELECTRICAL EQUIPMENT

- A. Install all equipment per the manufacturer's recommendations and the contract drawings.
- B. Install surface-mounted panelboards plumb, in conformance with NEMA PB 1.1.
- C. Install disconnect switches with centerline at 48" above finished floor, grade, etc. unless otherwise noted.
- D. Secure switchboard assemblies to foundation or floor channels.
- E. Secure disconnect switches to channel frames with spring-type fasteners and hardware intended for this specific use where wall mounted, unless otherwise indicated.
- F. Mount floor and wall mounted equipment utilizing Type 316 stainless steel anchors and fasteners of the size and number recommended by the manufacturer.
- G. Provide necessary hardware to secure the assembly in place.
- H. Provide 316 stainless steel fasteners for all other installation types.
- I. Inspect switchboards and panel boards for physical damage, proper alignment, anchorage, and grounding. Check proper installation and tightness of connections for circuit breakers, fusible switches, and fuses.
- J. Install and check all equipment in accordance with the manufacturer's recommendations.
- K. Ensure that equipment mounting pad locations are level to within 0.125 inches per three foot of distance in any direction. Notify Engineer immediately if any discrepancies are found in the field.
- L. Ensure that all equipment bus bars are torqued to the manufacturer's recommendations.
- M. Assemble all equipment shipping sections, remove all shipping braces and connect all shipping split mechanical and electrical connections.
- N. Provide filler plates for unused spaces in panelboards and switchboards.
- O. Provide typed circuit directory with protective plastic sleeve secured to inside of panel door for each branch circuit panelboard.
- P. Provide Micarta type labels located adjacent to each breaker operator, delineating equipment served for each circuit breaker in all switchboards.

- Q. Measure steady state load currents at each switchboard and panelboard feeder. Should the voltage difference measured at the equipment between any two phases exceed 20 percent, rearrange circuits to balance the phase loads within 20 percent. Take care to maintain proper phasing for multi-wire branch circuits.
- R. Measure and recording Megger readings phase-to-phase, phase-to-ground, and neutral-to-ground (four wire systems only).

3.17 UNIT RESPONSIBILITY

- A. Switchgear, panelboards, motor control centers, relays, switches, starters, etc. furnished under this Section of the specifications shall be supplied by the same manufacturer so as to give unit responsibility and ease of maintenance.

3.18 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections.
- B. Conductors
 1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors and conductors feeding the following critical equipment and services for compliance with requirements.
 2. Individually test 600-volt conductors for insulation resistance between phases and from each phase to ground.
 3. Test after cables have been installed and before they are placed into service with a low-resistance ohmmeter.
 4. Applied potential shall be 1000 Vdc for one minute in accordance with NETA recommendations.
 5. The ENGINEER shall be given written notice a minimum of two (2) days before the anticipated test date. The CONTRACTOR shall record the circuit designation and ohmmeter readings for each phase-phase and phase-ground measurement. This written record shall be submitted to the ENGINEER. The cost of any retest due to insufficient ohmmeter readings shall be the responsibility of the CONTRACTOR.
 6. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 7. Cables will be considered defective if they do not pass tests and inspections.
 8. Prepare test and inspection reports.
- C. Grounding and Bonding

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
 4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
 5. Grounding system will be considered defective if it does not pass tests and inspections.
 6. Prepare test and inspection reports.
 7. Report measured ground resistances that exceed the following values:
 - a. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
 - b. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
 - c. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
 - d. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).
 - e. Substations and Pad-Mounted Equipment: 5 ohms.
 - f. Handhole Grounds: 10 ohms.
 8. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.
 9. Prepare test and inspection reports.
- D. Provide personnel and equipment, make required tests, and secure required approvals from the Engineer and governmental agencies having jurisdiction.

- E. Provide written notice to the Engineer adequately in advance of each of the following stages of construction:
 - 1. In the underground condition prior to placing concrete floor slab, when all associated electrical work is in place.
 - 2. When all rough-in is complete, but not covered.
 - 3. At completion of the work of this Section.
- F. When material and/or workmanship are found to not comply with the specified requirements, replace items within three days after receipt of notice at no additional cost to the Owner.
- G. Provide a qualified field serviceman, representing the manufacturer of each piece of major electrical equipment, to make proper and complete adjustments of all adjustable devices, load switches, etc. after final installation and completion of all field wiring. Verify and approve all connections prior to any initial or test operation of equipment. Submit confirmation in writing by the manufacturer's authorized representative of said services to the Engineer.

3.19 CLEANING AND PAINTING

- A. Collect and remove from the premises all debris, scraps and other waste material after completion of work.
- B. Tamp and level all trench work.
- C. Remove excess dirt and debris, when and as directed by the Engineer.
- D. Thoroughly clean all electrical equipment, lighting fixtures, exposed conduit, enclosures and boxes of all foreign materials and paint in accordance with Section 09900 of these Specifications unless noted or directed otherwise.
- E. Clean any exposed threaded area of raceway of cutting oil and paint with a cold galvanizing compound prior to final finish painting.

3.20 ELECTRIC EQUIPMENT BY OTHERS

- A. The equipment manufacturer shall furnish all motors for equipment.
- B. Verify voltage, dimensions, extent, type, etc. of this and all other such electrical equipment.
- C. Furnish and install all electrical supply and control equipment and material required to put all the items in proper operative condition.

- D. Refer to other sections of these specifications for verification of other equipment and devices requiring electrical connections, wiring and devices not included in this section.
- E. Refer to other drawings for details not indicated on the electrical drawings.
- F. Prior to connecting any piece of such equipment, check the nameplate data against the information shown on the drawings and call to the immediate attention of the Engineer any discrepancies discovered.

3.21 PROJECT COMPLETION

- A. Test all 600-Volt service entrance and feeder wiring using an instrument, which applies a voltage of approximately 500 volts DC to provide a direct reading of resistance.
- B. Perform test on ground system utilizing Fall-Of-Potential method. Meg grounding systems to measure ground resistance, and provide not more than 25 ohms resistance, adding ground rods as necessary to achieve that level.
- C. Conduct all tests in presence of Engineer or his representative. Identify and properly record all readings. Submit readings to Engineer for acceptance.
- D. Measure voltages as directed by the Engineer and report to him these values.
- E. Provide entire system free from all shorts and grounds.
- F. Fully comply with local and national codes for equipment bonding and grounding.
- G. Test system in the presence of the Engineer and operate to his complete satisfaction in accordance with true intent of plans and specifications. Defray cost of all adjustments necessary to bring system up to standards set forth by Contract Documents at no additional cost.
- H. Thoroughly indoctrinate the Owner's operation and maintenance personnel in the contents of the operations and maintenance manual.
- I. On the first day the facility is in operation, for at least eight (8) hours at a time directed by the Engineer, provide a qualified foreman and crew to perform such electrical work as may be required by the Engineer.

3.22 FIELD SETTINGS

- A. Perform field adjustments of the protective devices, as required, to place the equipment in final operating condition. The settings shall be in accordance with the approved short circuit study, protective device evaluation study, and protective device coordination study.
- B. Necessary field settings of devices and adjustments and minor modifications to equipment to accomplish conformance with the approved short circuit and protective device coordination study shall be carried out by the Contractor at no additional cost to the Owner.

3.23 MEASUREMENT AND PAYMENT

- A. No separate measurement or direct payment will be made for this work and all costs for same shall be included in the price bid for the work to which it pertains.

END OF SECTION