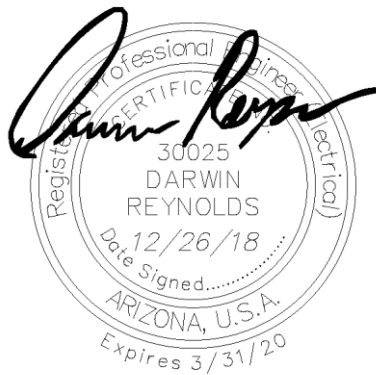


HALCHITA WATER TREATMENT PLANT
ELECTRICAL SPECIFICATIONS
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SECTION 16010

BASIC ELECTRICAL REQUIREMENTS

PART 1 -- GENERAL

1.01 SUMMARY

- A. Section Includes: Electrical general provisions as indicated, specified and required for constructing a complete, ready for use electrical system as described in these Contract Documents.
- B. Labor, materials, apparatus, and appliances essential to the complete functioning of systems described and indicated herein, or which may be reasonably implied as essential, whether mentioned in the Contract Documents or not, shall be furnished and installed by the Contractor. In case of doubt as to the work intended, or in the event of need for explanation thereof, Contractor shall refer to the Engineer for supplemental instructions.
- C. All items not specifically mentioned in these Specifications or noted on the Drawings, or on shop drawings, but which are necessary to make a complete and satisfactory, working electrical/instrumentation installation, shall be deemed to be included herein.
- D. All electrical equipment shall be capable of operating successfully at full-rated load, without failure, at an ambient air temperature of -20°C to 50°C, and specifically rated for an altitude of 4500 feet. Where these criteria cannot be met, ancillary equipment and/or special derating factors as approved by the Engineer shall be utilized.
- E. The Contractor shall perform all necessary saw cutting, core drilling, excavating, removal, shoring, backfilling, etc as required for the proper installation of conduits whether inside or outside of the building(s) and structure(s). The Contractor shall repair and patch where demolition has taken place in a manner to match existing original structure.

1.02 SUBMITTALS

- A. Submit documentation for review as described in individual Specification Sections for products requiring submission.
- B. Submit Division 16 in one submittal, or at a maximum, the following may be submitted as separate submittals for this project.
 - 1. Commodities (Sections 16010-16195) and Grounding (Section 16450)
 - 2. Mini-Power Centers (Section 16480) and Motor Controllers (Section 16481)
- C. Documentation must be arranged in numerical sequence corresponding with each Specification Section and article of each Section. Soft copies shall be in “pdf” format with “character recognition” and shall include the following as a minimum:

1. A cover page to identify the Contractor's name, name of the project, date and description, i.e. "Division 16 – Commodities".
 2. An index corresponding to each specification section with all addendum updates included. Each paragraph or bulleted item shall be check marked to signify compliance with each item and the information is included in the submittal package. If full compliance is not met for any reason, the non-compliance item shall be underlined and reference to a detailed written explanation of the deviation or non-compliance shall be provided for consideration.
 3. Bookmarks within each section for each major component within.
 4. Complete manufacturer name and model number of each item. Listing items "as specified" without both make and model or type designation is not acceptable.
 5. Descriptive Data: complete description, information, and performance data covering materials and equipment that are being proposed. Each component shall be clearly identified on each sheet. Refer to individual specification sections for additional submittal requirements.
- D. Hard copies shall be bound in 3-ring binders (2" max) and include all information as described above for soft copies. The binders shall include tabs corresponding to a neatly typewritten index. The binder cover and edge shall clearly identify the Contractor's name, name of the project, date and submittal number.
- E. Important Notice:
1. If Contractor's submittal departs from the Contract Documents, the Contractor shall make specific mention thereof on the submittal, otherwise review of such submittal by the Engineer shall not constitute review of such departure(s).
 2. The Engineer's submittal review is for the sole purpose of verifying general conformance with design intent and general compliance with Contract Documents. Approval of a submittal by the Engineer does not relieve the contractor of responsibility for correcting errors which may exist in the submittal or from meeting requirements of Contract Documents.
 3. **After material or equipment has been submitted and approved, no substitutions will be allowed, unless required per Contract Documents. Any equipment installed that is different than the approved shop drawings and submittals will be removed and replaced at the Contractor's expense.**
 4. The Contractor may be charged for costs incurred by the Engineer for third and subsequent submittal reviews. Cost for Engineer's review time shall be billed at the Engineer's standard hourly rates.
 5. Where calculations, sealed by a registered professional engineer, are required to be submitted, they will be reviewed for content and format but may not be reviewed for accuracy.

- F. For control panels, motor starters and other equipment requiring multiple terminations of components and devices, the Contractor shall submit detailed shop drawings on 11" x 17" size sheets consisting of point-to-point wiring diagrams, bill of materials, interior and exterior elevations with dimensions prepared by the equipment manufacturer or a UL 508A recognized system integrator.

1.03 RECORD DRAWINGS AND OPERATION AND MAINTENANCE MANUALS

- A. Record Drawings: On completion of work, Contractor shall furnish a complete set of Record Drawings and 11" x 17" size Shop Drawings which properly reflect final locations and sizes of conduit, equipment fixtures, controls, etc., as actually installed. Dimensions shall be included on the Contractor's as-built Drawings showing exact location of underground conduits.
- B. Operation and Maintenance (O&M) Manuals: Contractor shall provide O&M manuals for equipment and materials furnished under this contract. O&M manuals must be submitted and approved before final inspection of the project so that they may be used during startup. Soft copies shall be in "pdf" format with "character recognition" and shall include the following as a minimum:
1. A cover sheet to identify the Contractor's name, name of the project, date and description, i.e. "Electrical Equipment O&M Manual".
 2. Bookmarks within each section for each major component within.
 3. Complete manufacturer name and model number of each item.
 4. Descriptive data, component data sheets, wiring diagrams, control panel drawings, etc. from the approved submittals/shop drawings.
 5. Complete instructions regarding the installation, operation and maintenance of equipment involved. Instructions and documentation not related to the equipment furnished must be removed or crossed out. ***O&M manuals must be individually tailored to the project and equipment as furnished.***
 6. Complete nomenclature of replaceable parts, part numbers, current cost, name and address of nearest vendor of replacement parts. Information on equipment or components not related to equipment furnished must be removed or crossed out. ***O&M manuals must be individually tailored to the project and equipment as furnished.***
 7. Copy of warranties issued on the installation, showing dates of expiration.
- C. Hard copies, if required, shall be bound in 3-ring binders (2" max) and include all information as described above for soft copies. The binders shall include tabs corresponding to a neatly typewritten index. The binder cover and edge shall clearly identify the Contractor's name, name of the project, date and identified as "Electrical Equipment O&M Manual".

1.04 QUALITY ASSURANCE

- A. The Contractor performing the electrical construction and installation shall be a reputable **licensed** Contractor in the State of Utah to do electrical **commercial** construction. Where any electrical work indicated on the Drawings is over 600V, the Contractor must also be licensed to do work on High Voltage Electrical and Transmission Lines.
- B. The Contractor must be located within a 200-mile radius of the project and have been in that vicinity for a minimum of five (5) years.
- C. The Contractor must have a minimum of five (5) years experience as a Contractor installing electrical and instrumentation systems for other projects of similar type, size and requirements. If requested, the Contractor must submit documentation and list of references of recent projects similar to this one.
- D. All equipment furnished shall be new and of current design. Like equipment shall be of the same manufacturer.
- E. Unless otherwise indicated, all equipment and components shall be rated for use in the environment installed. Outdoor equipment shall be weatherproof or rated for outdoor use.

1.05 SPACE REQUIREMENTS

- A. Space Requirements: In the preparation of Drawings, a reasonable effort has been made to include equipment manufacturer's recommendations. Since space requirements and equipment arrangement vary according to manufacturer, the responsibility for initial access and proper fit rests with the Contractor. Final arrangement of equipment and service connections shall allow the unit to be serviced, including space to pull motors, change fuses, and operate switches. Minimum working clearances shall be as required by NEC and local codes.

1.06 COORDINATION

- A. Contractor shall coordinate with all other trades to avoid conflicts and interferences. No extra compensation will be allowed for changes made necessary due to interference between work of various trades.
- B. Any discrepancies noted in these contract documents or discrepancies between Drawings and actual field conditions shall be promptly brought to the Engineer for a decision. No extra compensation will be allowed for changes made by the Contractor without Engineer's consent.
- C. Carefully check and coordinate each device location and elevation. Also check routing of all conduits for conflicts with structures, mechanical piping, ducts, etc. to avoid conflicts.
- D. No ductwork or heating main or piping conveying fluids shall be installed directly over electrical equipment or electrical equipment rooms. Where this has been violated, the Contractor shall immediately notify the Engineer for assessment.

1.07 REGULATORY REQUIREMENTS

- A. Electrical work, including connection to electrical equipment integral with mechanical equipment, shall be performed in accordance with the latest published regulations of the National Electrical Code (NEC), State and local codes, and according to the latest Institute of Electrical and Electronic Engineers (IEEE); American National Standards Institute (ANSI); American Society for Testing and Materials (ASTM); Insulated Cable Engineers Association (ICEA); National Electrical Manufacturers Association (NEMA) Standards; and the latest published regulations of the Federal Occupational Safety and Health Act (OSHA). When applicable, the material used in the performance of the electrical work shall be listed by the Underwriters' Laboratories, Inc. (UL) for the class of service for which they are intended.
- B. Control panels shall be assembled and wired by a UL 508A recognized panel shop. All control panel components shall be UL recognized or ground fault protected per UL 508A fabrication standards. Each control panel assembly shall be fabricated according to UL 508A Standards and shall bear a serialized UL 508A label.

1.08 WARRANTY

- A. In addition to specific warranties required by the Specifications, the Contractor shall leave the entire installation in complete working order and free from defects in materials, workmanship or finish. Contractor shall repair or replace at his own expense any part that may develop defects due to faulty material or workmanship during the tests and within a period of one year after the work is accepted by the Engineer and Owner. Contractor shall repair or replace existing equipment and work that is damaged during the repair of defective apparatus, materials or workmanship.
- B. All manufacturer's warranties shall be filled out in their entirety by the Contractor for the Owner using the Owner's name and address. Unless otherwise specified, equipment warranty periods will commence on date of final acceptance.

1.09 DRAWINGS

- A. Clarity and Legibility: For purposes of clarity and legibility, the Drawings are diagrammatic only. Drawings are not intended to show every fitting, junction, gasket or component necessary, nor every difficulty that may be encountered during installation. Conduit routing may be adjusted in the field. Size and location of equipment are drawn to scale wherever possible. Contractor shall refer to related data in all Contract Documents and shall verify this information on site.
- B. Instrumentation and control drawings are provided to indicate the control strategy intent only. Final circuitry shall be as determined by the Contractor or his vendors. Actual wiring diagrams shall be provided by the Contractor and reviewed by the Engineer for a fully functional system as intended.

1.10 REFERENCES

- A. The specifications reference known standards and codes. Each such standard referred to shall be considered a part of the Specifications to the same extent as if reproduced therein in full. The following is a representative list of such Associations, Institutes and Societies, together with the acronym by which each is identified.

AASHTO	American Assoc of State Highway and Transportation Officials
AIEE	American Institute of Electrical Engineers
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
ICEA	Insulated Cable Engineers Association
IEEE	Institute of Electrical and Electronics Engineers
IES	Illumination Engineering Society
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NETA	National Electrical Testing Association
NFPA	National Fire Protection Association
UL	Underwriter's Laboratories, Inc.

- B. Every reference in the Specifications shall mean the latest printed edition of each in effect at the Contract Date.

1.11 UTILITY SERVICE

- A. Contractor shall contact NTUA to provide or remove electrical service(s) to the site. This includes the permanent as well as any temporary service requirements. The Contractor shall provide all necessary labor and material required to obtain this service(s) in accordance with utility requirements. Any utility company fees and charges associated with providing, maintaining and usage of these services shall be paid by Owner.
- B. Submit copies of electrical service entrance equipment to NTUA for approval prior to releasing switchgear for fabrication. A copy of this approval letter shall be submitted to the Engineer.

1.12 ABBREVIATIONS

- A. References on the Drawings to various abbreviations have been made. The following is a representative list of such abbreviations together with the acronym by which each is identified.

AFF	Above finished floor
AFG	Above finished grade
AI	Analog input
AO	Analog output
ATS	Automatic transfer switch
C	Conduit
C/B	Circuit Breaker
CKT	Circuit
CPT	Control power transformer

Cu	Copper
DI	Digital input
DIST	Distribution
DO	Digital output
DWG	Drawing
GND	Ground
GFCI	Ground Fault Circuit Interrupter
GFI/GFP	Ground Fault Indication/Protection
GRS	Galvanized Rigid Steel Conduit
HPS	High Pressure Sodium
IMC	Intermediate Metal Conduit
INST	Instrument
LED	Light Emitting Diode
MBJ	Main bonding jumper
MCB	Main Circuit breaker
MCC	Motor Control Center
MCP	Motor Circuit Protector
MFR	Manufacturer
MLO	Main Lug Only
NC	Normally Closed
NO	Normally Open
NTUA	Navajo Tribal Utility Authority
PC	Personal computer
PLC	Programmable logic controller
PR	Pair
REQ'TS	Requirements
RTU	Remote terminal unit
SES	Service entrance section
SPD	Surge Protective Device
RMC	Rigid Metal Conduit (GRS or IMC)
RVSS	Reduced Voltage Soft Starter
SWBD	Switchboard
TTB	Telephone Terminal Board
TSP	Twisted Shielded Pair
TST	Twisted Shielded Triad
VFD	Variable frequency drive
WP	Weatherproof

****END OF SECTION****

SECTION 16110

RACEWAYS

PART 1 -- GENERAL

1.01 SUMMARY

- A. Section Includes: Metallic and non-metallic wiring raceways.

1.02 SUBMITTALS

- A. Product Data: Submit manufacturer's data demonstrating compliance with this specification including couplings, fittings, bushings, and hangers.
- B. Submit on the proposed method for separating conduits in underground ductbanks.

1.03 QUALITY ASSURANCE

- A. Perform work in accordance with NECA Standard of Installation and NFPA 70.

1.04 RELATED WORK

- A. Specification Section 16195, Electrical Identification

PART 2 -- PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Conduit:
 - 1. Rigid metal, intermediate and EMT:
 - a. Allied
 - b. Republic
 - c. Triangle Conduit and Cable Co.
 - d. Wheatland
 - 2. PVC coated rigid steel:
 - a. Ocal
 - b. Robroy
 - c. Calbond
 - d. Gafco Green
 - 3. Flexible and flexible water-tight:
 - a. Alflex Corp.
 - b. Carlon Products Corp.
 - c. Carol Cable Co., Inc.
 - d. Electri-Flex
 - e. Sealtite
 - 4. Non-metallic PVC:
 - a. Can-Tex

- b. Carlon
 - c. PW Eagle/JM Eagle
- 5. Conduit supports and hangers:
 - a. Caddy
 - b. Thomas and Betts
 - c. Appleton
 - d. Crouse-Hinds
 - e. B-Line Systems
- 6. Supporting Channel:
 - a. G-Strut
 - b. Unistrut
 - c. B-Line

2.02 MATERIALS

- A. Metallic Conduit:
 - 1. Rigid steel:
 - a. Hot dipped galvanized rigid steel; meet ANSI C80.1 and ASTM A153; UL labeled and meet UL Standard No. 6.
 - b. All conduit bodies and fittings shall be threaded. Threadless couplings shall not be used unless specifically approved by the Engineer.
 - c. All conduit body covers shall be secured with machine screws threaded onto the conduit body. Covers secured by snaptight or wedge-nuts are unacceptable.
 - d. Where PVC coated rigid steel conduit is indicated on the Drawings, the conduit shall be galvanized steel with a factory installed PVC coating. All conduit fitting, boxes, connectors, etc. shall also be PVC coated by the factory.
 - e. No aluminum conduit shall be permitted unless approved by the Engineer.
 - 2. Intermediate: Shall be same as rigid above with thinner wall.
 - 3. Electrical metallic tubing (EMT or Thin-wall) shall be:
 - a. Galvanized; meet ANSI C80.3; UL labeled; marked with manufacturer's name.
 - b. Thin-wall conduit fittings for damp or wet locations shall be of the regular watertight design, with hexagonal nuts and center portions requiring the use of a wrench during installation.
 - c. Setscrew type fittings are not permitted under any circumstances.
 - 4. Flexible conduit:

- a. UL-listed flexible rubber or plastic coated metallic type with watertight ferrule and sleeve type connectors. Standard steel type flexible conduit is unacceptable.
 - b. ANSI/NEMA FB1 steel connectors. Connectors must be PVC coated where installed in corrosive environments or where PVC conduit or PVC coated GRS conduit is specified.
- B. Non-Metallic PVC Conduit:
 - 1. Rigid non-metallic conduit Polyvinyl Chloride (PVC) type II PVC shall be schedule 40, suitable for use with 90 degree rated wire. Conduit shall bear UL labels for above and below ground use.
 - 2. All PVC conduit 1-1/4 inch and larger with bends greater than 45° shall utilize factory bends.
 - 3. Where the enclosure or raceway is subject to physical damage, conductors shall be installed in rigid metal conduit, intermediate metal conduit, Schedule 80 rigid nonmetallic conduit or equivalent.
 - 4. Meet UL standard #651.

PART 3 -- EXECUTION

3.01 INSTALLATION

- A. General:
 - 1. Raceways shall be concealed, where possible, unless otherwise indicated on the Drawings. When exposed, confirm the exact routing with the Engineer prior to roughing in.
 - 2. Sizing: Minimum conduit sizes are indicated on the Drawings. The Contractor may choose to install larger conduit for ease of installation or wiring pulling at no additional cost to the Owner. If conduit or raceway size is not indicated on the Drawings, raceways shall be sized per NEC. Unless otherwise indicated, minimum conduit size shall be 3/4 - inches.
 - 3. Unless otherwise indicated, all exposed conduits to be rigid metal conduit GRS or IMC. All direct buried or concrete encased conduits to be Schedule 40 PVC.
- B. Conduit:
 - 1. Conduit shall: Have openings temporarily plugged, using “pennies” or equal, to exclude plaster or other foreign materials; be reamed after cutting; have joints cut square, and butt solidly into fittings; have the ends terminated in a proper bushed fitting, be rigidly supported so as to prevent undue stress or strain on the couplings and connectors; be swabbed before conductors are pulled in.
 - 2. After installation, seal the openings of all conduits in all enclosures using Type DC duct sealing compound/putty as manufactured by O-Z/Gedney or equal.

3. Concealed conduits shall be run in a direct line with long sweep bends and offsets. Horizontal runs shall be run with a slight incline, to prevent low spots or pockets (for drainage).
4. Conduits shall be continuous from outlet to outlet, from outlets to cabinets, pull or junction boxes and shall be secured to boxes with lock nuts and bushings in such a manner that each system shall be electrically continuous throughout. "Erickson" couplings shall be used where required. No running threads shall be cut.
5. Install conduit systems completely before conductors are pulled. Conduits shall be securely supported at proper intervals to structures with steel clamps, or conduit hangers or by special supporting assemblies when indicated on the Drawings.
6. Conduit terminations shall contain insulated bushings. Provide grounding type bushings where steel conduit is stubbed into nonmetallic enclosures, stubbed up in the base of freestanding enclosures or where locknuts cannot assure proper ground continuity between metallic enclosures and the steel conduit. Provide service entrance and transformer connection conduits with grounding type bushings.
7. Exposed conduits shall be installed parallel to walls, floor and ceilings or at right angles to the building lines. Exposed bends shall be used only where approved. Covers shall be secured to bodies with machine screws.
8. IMC: May be used in lieu of heavy wall rigid, unless otherwise indicated.
9. Electrical metallic tubing (EMT) or "Thin-wall" may not be used except where specifically indicated on the Drawings or as directed by the Engineer.
10. Hickey bends shall not be used for 1-inch and larger conduits. Either manufactured elbows or bends fabricated in a bending machine shall be used. The radius of the inner edge of bends shall be six times the internal diameter of the conduit for conduit sizes up to 2 ½-inches and 12 times internal diameter for 3-inches conduits and larger. A run of conduit between outlet and outlet, between fitting and fitting, or between outlet and fitting shall not contain more than 360° of total bends.
11. Conduit shall not be run above or below water piping, and must be individually supported.
12. In wet locations, and in locations where walls are frequently washed, the entire conduit system, including boxes and fittings used, shall be installed and equipped to prevent water from entering conduit. Conduit shall be so mounted so that there is at least ¼-inch air space between conduit and wall or similar supporting surface.
13. Unless otherwise indicated, PVC coated rigid metal conduit shall be used in Chlorine Rooms.
14. Schedule 40 PVC conduit may be used for buried conduit installations as permitted by the NEC and local codes except where galvanized rigid steel

is specified. Couplings, transition fittings, adhesives, primer and installation procedures recommended by the conduit manufacturer and all applicable codes must be strictly followed.

15. Install liquid-tight flexible metal conduit at motors, transformers and equipment which are subject to vibration or require movement for maintenance purposes. Provide necessary reducer where equipment furnished cannot accept 3/4-inch size flexible conduit. Limit flexible conduit length to 3-foot maximum.

C. Conduit Supports and Hangers:

1. Conduits shall be individually fastened securely in place on maximum of 8-feet intervals for 1-inch conduit or less and 5-feet intervals for conduits over 1-inch and within 3-feet of each conduit run termination. Use only supports, hangers and fasteners specifically designed for supporting electrical conduits.
2. Where two or more conduits 1-inch or larger run parallel, trapeze hangers may be used consisting of concrete inserts, threaded solid rods, washers, nuts and galvanized "L" angle iron, or 1-5/8" strut cross members. Such conduits shall be individually fastened to the cross member of every other trapeze hangers with galvanized cast two hole straps, clamp backs, bolted with proper size cadmium machine bolts, washers and nuts. If adjustable trapeze hangers are used to support groups of parallel conduits, U-bolt type clamps shall be used at the end of a conduit run and at each elbow. J-bolts, or approved clamps, shall be installed on each third intermediate trapeze hanger to fasten each conduit.
3. Hangers shall be made of durable materials suitable for the application involved and shall be painted with two coats of oil paint. Where excessive corrosive conditions are encountered, hanger and strut assemblies shall be protected after fabrication by sherardizing or galvanizing, special paint or other suitable preservative methods.
4. For mounting on concrete or brick construction, insert anchors shall be installed with round head machine screws. In wood construction, round head wood screws shall be used. In brick, inserts shall be near center of brick, not near edge or in joint. Where steel members occur, drill and tap, and use round head machine screws.

- D. Sleeves, Inserts, etc.: Lay out and install work in advance of the laying or pouring of floors and erection of walls. Furnish and install sleeves that may be required for openings through floors, wall, etc. Where plans call for conduit to be run exposed, furnish and install inserts and clamps for the supporting of conduit. If this Contractor does not properly install sleeves and inserts required, he will be required to do the necessary cutting and patching later, at his own expense, to the satisfaction of the Engineer.

- E. Installation of Underground Conduits:

1. Install underground conduit as indicated on the Drawings. Backfill material around the conduits must be clean-fill (dirt with rocks no larger than ½-inch).
2. Conduit bends shall have long sweep radius curves instead of standard elbows where indicated on the Drawings. All PVC conduit bends greater than 45° shall be factory-made for conduits larger than 1-inch.
3. All underground PVC conduit shall be buried a minimum of 24-inches below finished grade, except when located below a concrete slab or freestanding electrical equipment. Conduit shall be installed deeper than 24-inches wherever required to avoid existing piping, tunnels, or other obstructions.
4. Underground conduits in ductbanks shall be separated and supported with pre-manufactured plastic chairs, unless submitted and approved otherwise, installed at 5-foot intervals in the trench.
5. ***After duct is in place, notify the Engineer prior to backfill or concrete pour for inspection.*** Failure to do so will result in removal of all backfill material to expose the conduits for inspection.
6. During backfill, provide plastic warning tape at 12-inches below finished grade over underground electrical installations which reads, “Caution - Buried Electrical Line Below”.
7. PVC conduits are permitted to be stubbed up into freestanding electrical enclosures. Where conduit stubs up out of the earth and is exposed, any portion of the conduit with less than 24-inches of cover shall be PVC coated rigid metal conduit or galvanized rigid metal conduit wrapped with 20-mil rubber tape half-lapped to a thickness of 40-mils.
8. Where terminating PVC conduit in a freestanding enclosure, underground junction box, manhole/handhole or other similar locations, provide each termination with a bell end.
9. Rigid metal conduit terminations shall contain insulated bushings. Provide grounding type bushings where steel conduit is stubbed into nonmetallic enclosures, stubbed up in the base of freestanding enclosures or where locknuts cannot assure proper ground continuity between metallic enclosures and the steel conduit. Install grounding type bushings on all service entrance and utility transformer connection conduits.
10. Spare conduits shall be capped with an approved plug.
11. Before pulling cables into underground conduits, pull a mandrel ¼-inch smaller than the conduit inside diameter and pulled through each conduit, and if any concrete or obstructions are found, the Contractor shall remove them and clear the conduits. Underground conduits shall be swabbed before cables are pulled in.
12. After duct runs are completed and set, backfill the trenches and tamp thoroughly to 90 percent compaction. Tamp to 95 percent compaction

where conduits are located under a roadway. Compaction shall be witnessed by the Engineer.

13. Contractor shall label all conduits in underground ductbanks with a black marker before calling for an inspection.

3.02 CONDUIT MARKERS

- A. All conduits with conduit designations indicated on the Drawings shall be identified at each termination. See Section 16195 - Electrical Identification for conduit tag requirements.

****END OF SECTION****

SECTION 16120
WIRES AND CABLES
(600V OR LESS)

PART 1 -- GENERAL

1.01 SUMMARY

- A. Section Includes: Cables and wires rated 600 volts or less, as specified, including wiring of all devices.

1.02 SUBMITTALS

- A. Product Data: Submit manufacturer's data on all power, signal and communication cables demonstrating compliance with this Specification.

1.03 QUALITY ASSURANCE

- A. Comply with the following Codes and Standards:
 - 1. NFPA 70 (NEC)
 - 2. UL listing for materials.
 - 3. ICEA S-66-524
 - 4. NEMA WC-7
 - 5. ASTM B-3 or B-8

PART 2 -- PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Cable:
 - 1. General Cable
 - 2. Okonite
 - 3. Southwire
 - 4. Encore
- B. Connectors:
 - 1. Ideal
 - 2. Burndy Corp.
 - 3. Thomas and Betts Co.
 - 4. O.Z. Gedney
 - 5. Minnesota Mining & Manufacturing (3M)

2.02 MATERIALS

- A. Conductors for wire and cable shall be stranded copper with 98 percent conductivity and shall be tinned or untinned in accordance with established standards for the type of insulation around the conductors. Solid conductors are not acceptable.

- B. Wire and cable shall be stamped approximately every two feet to indicate voltage, type, temperature rating, and other significant data or warnings.
- C. Conductors for general purpose wiring shall meet the following requirements:
 - 1. Power: Type XHHW-2. Minimum conductor size for power shall be No.12 AWG.
 - 2. Control: Type XHHW-2 for conductors run in conduit, minimum size No.14 AWG. Type MTW for conductors contained in control panels, minimum size No.14 AWG or No.16 AWG when protected by an overcurrent device of 10A or less.
 - 3. Analog Signal: Twisted shielded pair (TSP) or triad (TST) with #18 AWG drain wire and an overall PVC jacket rated 600V and rated for wet locations, minimum conductor size No.16 AWG.
 - 4. Ethernet: Category 5e, #24AWG, (4) twisted pairs with shield providing 100% coverage, #24AWG drain wire and an overall PVC jacket rated for wet locations (where applicable) and 600V.
- D. Wire Pulling Lubricant: Lubricant shall be UL listed and be of a consistency that will not leave an obstruction or tackiness that prevents pulling out wires in the future. No soap flakes or vegetable soaps will be permitted. Lubricant in shall be Ideal Wire Lube or equal.
- E. Cable Ties: Wiring in panels, cabinets, etc. shall be neat and tied with “Ty-Rap” T&B “TY-5418” series, or Panduit Co. “Cable Wrap”. Cable ties used in outdoor locations shall be UV stabilized.
- F. Terminations:
 - 1. 3-M Scotchlok lugs and connectors - copper.
 - 2. O-Z solderless connectors, grounding devices, power connectors, armored cable fittings, and cable terminations.
 - 3. Burndy - copper - all types as appropriate for cable size and configuration.
- G. Connector material shall be compatible with conductor material to prevent corroding, differences in coefficients of expansion or electrolysis.

PART 3 -- EXECUTION

3.01 INSTALLATION

- A. Install wires and cables in NEC approved raceways (Section 16110). All wire and cable must be installed in a raceway, unless otherwise indicated on the Drawings.
- B. Branch circuit and feeder conductors shall have insulation with the following color. Phase tape is unacceptable.
 - 1. Grounding conductor-Green.
 - 2. Neutral - White.
 - 3. 120/240V Phase A - Black.
 - 4. 120/240V Phase B - Red.
 - 5. 120/208V Phase A - Black.

6. 120/208V Phase B - Red.
 7. 120/208V Phase C - Blue.
 8. 277/480V Phase A - Brown.
 9. 277/480V Phase B - Orange.
 10. 277/480V Phase C - Yellow.
- C. 6-inch minimum loops shall be provided at each outlet, device or luminaire. Unused wires in outlet boxes, shall be rolled up, connected together and taped or capped with wire nuts. Mark bundled, unused spare wires as “SPARE FROM [origination]”.
- D. Branch circuit sizing: Where wire size is not indicated on the Drawings, NEC and local codes shall govern. However, minimum branch circuit conductor size shall be No. 12 AWG.
- E. Pulling Cables: Wires and cables shall be carefully handled during installation. Lubricant used for pulling in wires and cables shall be used. Use a dynamometer when pulling conductors by mechanical means.
- F. Communication and signal cables shall be run in separate raceways from power wiring. Keep separated from power wiring in control panels, wireways and junction boxes. Keep separated from power wiring raceways by a minimum of 12-inches.
- G. Bending radius: Do not exceed the manufacturer’s maximum bending radius.

3.02 SPLICES AND TERMINATIONS

- A. Splices:
1. Splices in conductors shall not be used unless otherwise indicated on the Drawings or approved by the Engineer.
 2. Where splices are allowed or necessary, they shall be mechanically strong and well made so that the electrical resistance of a joint shall not exceed that of 2-feet of the conductor.
 3. Splices shall be made only in junction boxes and never in conduit.
 4. Above Grade Splices:
 - a. Utilize wing nut solderless connectors for splicing No. 8 AWG and smaller conductors. Follow manufacturer’s recommendations for sizing, stripping, twisting, etc.
 - b. Utilize insulated butt connectors crimped end-to-end for splicing No. 6 AWG and larger conductors. Follow manufacturer’s recommendations for sizing, stripping and crimping.
 5. Below Grade Splices:
 - a. Utilize waterproof splice kits or wing nut solderless connectors with cast-resin waterproofing for splicing No. 8 AWG and smaller conductors. Follow manufacturer’s recommendations for sizing, stripping, twisting, etc.

- b. Utilize insulated butt connectors crimped end-to-end with cast-resin waterproofing for splicing No. 6 AWG and larger conductors. Follow manufacturer's recommendations for sizing, stripping and crimping.
 - c. Utilize insulated butt connectors crimped end-to-end for all below grade splices or No. 6 AWG and larger conductor splices above grade. Follow manufacturer's recommendations for sizing, stripping and crimping.
- B. Motor terminations: Ring type, crimped connectors shall be installed on all conductors and bolted together back-to-back. For terminations with No.6 and smaller wire, use 10-24 bolts. Use bolts that match the connector bolthole size for all other motor terminations. Apply one layer of cambric tape followed by three layers of rubber tape and finally, top with one layer of black vinyl tape.
- C. Non-motor terminations: Use ring or fork type, crimped connectors for all screw-on terminations. Wrapping wire around a binding post is unacceptable.
- D. Where special tools are required to properly install the particular connector the special tools must be used.

3.03 WIRE MARKERS

- A. All conductors shall be labeled at each termination and splice. See Section 16195 - Electrical Identification for wire marker requirements.

****END OF SECTION****

SECTION 16130

BOXES

PART 1 -- GENERAL

1.01 SUMMARY

- A. Section Includes: Outlet boxes, pull and junction boxes and underground junction boxes.

1.02 SUBMITTALS

- A. Product Data: Submit manufacturer's data for standard outlet boxes up to six gang, including floor type demonstrating compliance with specification requirements and Drawings.
- B. Shop Drawings: Submit drawings for special pull, outlet, and junction boxes demonstrating compliance with NEC and specification requirements. Drawings shall indicate box dimensions and locations in building.

1.03 QUALITY ASSURANCE

- A. Comply with the following Codes and Standards:
 - 1. NEMA 250
 - 2. NFPA 70
 - 3. UL listing for materials.

PART 2 -- PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Appleton Electric
- B. Crouse-Hinds
- C. Killark
- D. Raco
- E. Hoffman Engineering Co.
- F. O.Z. Gedney Co.
- G. Steel City
- H. Hubbell
- I. Rittal

2.02 MATERIALS

- A. Outlet boxes for concealed conduits and flush-mounted wiring devices shall meet the following requirements:

1. Stamped, one piece, galvanized steel.
 2. Proper size and shape for conduits entering them.
 3. UL listed for their application.
 4. ANSI/NEMA OS-1 for galvanized steel; ANSI/NEMA OS-2 for non-metallic.
- B. Outlet boxes for exposed conduit systems and exterior locations shall be of the threaded-hub, cast-metal, conduit type fitting suitable for the wiring devices to be installed. Covers (blank, switch, receptacle, etc.) shall be the type specifically designed to fit the specified boxes.
- C. Above grade electrical junction and pull boxes shall be sheet metal with an ANSI 61 gray color with size and type as indicated on the Drawings. NEMA rating shall be as indicated on the Drawings. Where a NEMA rating is not indicated, outdoor boxes shall be NEMA 3R and indoor boxes shall be NEMA 12. Box sizes shall be as indicated on the Drawings. Where sizes are not indicated or larger size is required to meet code, the box size shall be increased as required by the National Electrical Code.
- D. Wireways and troughs:
1. Wireways shall be sized as indicated on the Drawings or as required by the National Electrical Code. Where sizes are not indicated or larger size is required to meet code, the wireway shall be sized such that the cross-sectional area of the wireway at any one point does not exceed 40% per the National Electrical Code.
 2. Cover: Hinged with removable latches where feasible.
 3. UL listed for steel enclosed wireway or auxiliary gutter.
 4. Furnished complete with covers, elbows, tees, junction boxes, end covers, connectors and hangers.
 5. Unless otherwise indicated, wireways shall be NEMA 1 for indoor applications and NEMA 3R for outdoor and NEMA 4X for corrosive atmospheres.
 6. Wireways in outdoor locations shall be fully gasketed.
- E. Underground junction boxes:
1. Construction: Electric underground junction boxes shall be precast concrete and size as indicated on the Drawings. Underground junction boxes shall have precast concrete extensions.
 2. Covers: Covers shall be rectangular, reinforced concrete and have the text "ELECTRIC" cast into the cover.
 3. Approved Manufacturer: Christy, or equal.
- F. Fittings, hangers, fastenings, etc., shall be of material that will prevent chemical reaction between itself and conduit or device it is fastening or supporting.

PART 3 -- EXECUTION

3.01 BOX LOCATIONS

- A. Location of Boxes: In order that boxes may be placed in proper locations, the Contractor shall familiarize himself with the details of these spaces and carefully lay out boxes so that the equipment or piping of other trades passing under, over, across or in close proximity to same, will not cause these boxes to be inaccessible for use or maintenance. Contractor shall consult with other Contractors and trades on the project and obtain details of the project to locate outlet boxes properly.
- B. Contractor shall be responsible for the exact and proper location of the various portions of his work. Consult the Drawing and details.
- C. Mounting Heights: The exact mounting height of each switch, receptacle, light fixture outlet, etc., shall be confirmed on the premises in conference with the Engineer. Unless otherwise indicated, receptacles to be mounted at 18-inches and light switches to be mounted at 42-inches above finished floor/grade.

3.02 INSTALLATION

- A. No thru-boxes shall be permitted.
- B. Boxes shall meet the following requirements:
 - 1. Proper size and shape for conduits entering them.
 - 2. Installed so that device and/or cover plates shall be tight and plumb with wall finish.
 - 3. Have unused openings closed with knock-out closures.
 - 4. Securely fastened to building or structure.
- C. Surface-mounted outlet boxes shall meet the following requirements:
 - 1. Outdoor boxes shall be cast steel or cast aluminum with threaded hubs.
 - a. Fastened with not less than two Paine, Phillips, Ackermann-Johnson, or equivalent, screw anchors and round head machine screws on brick and concrete walls or ceilings.
 - b. Under no circumstances will drilling of cast boxes be allowed.
 - c. PVC coated boxes shall be used for installations with PVC coated rigid steel conduit.
 - d. Be provided with a vapor-proof gasket in wet locations or where indicated as "WP" (weatherproof) on the Drawings.
 - e. Install a weatherproof-while-in-use cover on all outdoor receptacles.
 - 2. Bell boxes may be used for indoor applications where rigid steel or IMC conduit is required.
- D. Flush-mounted outlet boxes shall:
 - 1. Be solid ganged boxes for more than two devices.
 - 2. Contain a plaster ring to bring the wiring device attachment points within 1/4-inch of the finished wall surface.

3. Be installed so that device covers are tight and plumb with wall finish.
 4. Be installed as close as possible to the lock side of door trim for light switches.
- E. Bracket outlets shall be level and centered on columns or above doors when installed in these locations.
- F. Pull boxes and junction boxes shall be:
1. Installed in runs of conduit more than 100-feet in length or the equivalent of four 90-degree bends.
 2. Entirely accessible.
 3. Securely mounted to building structure independent of the conduits connected to them.

****END OF SECTION****

SECTION 16140
WIRING DEVICES

PART 1 -- GENERAL

1.01 SUMMARY

- A. Section Includes: Wiring devices such as but not necessarily limited to power receptacles and light switches.

1.02 SUBMITTALS

- A. Product Data: Submit manufacturer's data for each wiring device including device covers demonstrating compliance with these Specifications and UL labeling.

1.03 QUALITY ASSURANCE

- A. Comply with the following Codes and standards:
 - 1. NEMA
 - 2. UL listing
 - 3. NFPA 70

PART 2 -- PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Hubbell
- B. Leviton
- C. Bryant
- D. Crouse-Hinds
- E. Pass & Seymour

2.02 MATERIALS

- A. Light switches and receptacles shall meet NEMA WD1 and WD6 standards, be UL listed and be Heavy Duty, **Industrial** Specification grade. Commercial specification grade wiring devices are not acceptable.
- B. Amperage rating of each wiring device shall match the circuit's overcurrent device amperage rating to which it is connected.
- C. Wiring devices shall have an ivory finish unless otherwise specified.
- D. Power receptacles shall be the grounded type. Furnish ground fault circuit interrupter (GFCI) type where indicated on the Drawings or as required by the NEC.
- E. All GFCI receptacles shall be listed weather-resistance (WR) type receptacles.
- F. Light switches shall be the quiet type.

- G. Wiring Device Coverplates:
1. Unless otherwise indicated, coverplates installed indoors or in control panels shall be brushed anodized aluminum.
 2. Weatherproof locations: Wiring devices installed outdoors or where identified on Drawings with “WP” shall contain a gasketed coverplate UL approved for wet locations.
 3. Where weatherproof-while-in-use coverplates are indicated on the Drawings or required by NEC, power receptacles shall be provided with a cover that is listed for “extra duty” and maintains UL approval for wet locations when a cord is plugged into the receptacle.

PART 3 -- EXECUTION

3.01 INSTALLATION/APPLICATION

- A. Devices and coverplates shall be plumb and parallel to adjacent surfaces or trim. Flush-mounted devices must be flush with finished wall surfaces and the coverplates must be tight to surfaces over which they are installed.
- B. Receptacles identified as GFCI or when required by the NEC shall have individual GFCI receptacles installed for each outlet. Installing a single GFCI receptacle and standard receptacles connected to the load side of the single GFCI receptacle is unacceptable.

3.02 FIELD QUALITY CONTROL

- A. Contractor shall verify that the openings have been properly patched around devices without damage to devices.
- B. Damaged or painted devices shall be replaced or cleaned as directed by the Engineer.

****END OF SECTION****

SECTION 16195
ELECTRICAL IDENTIFICATION

PART 1 -- GENERAL

1.01 SECTION INCLUDES

- A. Nameplates and labels
- B. Wire and cable markers
- C. Conduit markers
- D. Section does not include arc-flash labels

1.02 REFERENCES

- A. ANSI/NFPA 70 - National Electrical Code.
 - 1. NEC 110-22 Identification of Disconnecting Means
 - 2. NEC 200-6 Means of Identifying Grounded Conductors
 - 3. NEC 200-10 Identification of Terminals
 - 4. NEC 210-5 Identification for Branch Circuits
 - 5. NEC 215-8 Means of Identifying Conductor with the Higher Voltage to Ground
 - 6. NEC 230-70, (B) Service Equipment, Marking
 - 7. NEC 310-11 Marking
 - 8. NEC 310-12 Conductor Identification
 - 9. NEC 400-22 Grounded-Conductor Identification
 - 10. NEC 400-23 Equipment Grounding Conductor Identification
 - 11. NEC 408-13 Panelboard circuit identification
- B. UL standard 224- Standard for Extruded Thermoplastic Insulating Tubing.

1.03 SUBMITTALS

- A. Product Data: Provide catalog data for the following:
 - 1. Wire and cable marking system
 - 2. Nameplate materials and fasteners
 - 3. Conduit markers

1.04 REGULATORY REQUIREMENTS

- A. Conform to requirements of ANSI/NFPA 70.
- B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.

PART 2 -- PRODUCTS

2.01 NAMEPLATES AND LABELS

- A. Engraved laminated plastic nameplates with black letters on white background shall be installed on the following as a minimum:
 - 1. Electrical distribution equipment enclosures
 - 2. Disconnect switches and motor controllers
 - 3. Control panels and cabinets
 - 4. Each motor controller or control panel door mounted device
 - 5. Major components, control relays and terminal block strips mounted on the backpanel of control panels
- B. Letter Size:
 - 1. Use 3/8-inch letters for identifying electrical distribution equipment enclosures and other large control panels and cabinets. Use 3/16-inch letters for identifying individual control panel components (inside or out) and small control panels/enclosures.

2.02 WIRE MARKERS

- A. Manufacturer: Raychem Corporation Model ShrinkMark or equal.
- B. Description: heat shrinkable radiation cross-linked, thermally stabilized, modified polyolefin sleeves with 3:1 shrink ratio. Markers shall be UL Standard 224 recognized.
- C. Sleeves shall be smear resistant prior to shrinking and achieve mark permanency when shrunk without the need for permatizing equipment. Sleeves should achieve mark permanency when standard ballpoint pens or high-carbon content fabric ribbons are used. The markers shall be flattened and mounted on a carrier suitable for use with commercially available print equipment. Markers shall be printable on both sides. Markers shall be resistant to common industrial fluids including Freon TF, Isopropyl alcohol, and Ethylene Glycol.
- D. Locations: Each conductor at each termination and splice.
- E. Legend:
 - 1. Power and Lighting Circuits: Branch circuit or feeder number indicated on the Drawings.
 - 2. Control Circuits: Control wire number indicated on approved schematics, interconnection diagrams and shop drawings.
 - 3. Wire numbers shall be the same at both ends of the wire.

2.03 CONDUIT MARKERS

- A. Conduit markers shall be 19 gauge, 1 1/2-inch diameter round brass (Brady Part No. 23210 or equal) with engraved, black-filled, 1/4-inch Arial font lettering. Markers shall identify conduit number or designation as indicated on the Drawings. If a conduit is not identified on the Drawings, the Contractor shall consult the Engineer for the proper identification.

PART 3 -- EXECUTION

3.01 NAMEPLATES

- A. Install nameplates parallel to equipment lines.
- B. Secure nameplates to the exterior of electrical equipment using UL-508A approved die and tapped stainless steel screws (APM SEELSKREW or equal).
- C. Secure nameplate to inside surface or backpanels of control panels with a permanent adhesive (Liquid Nails or equal).

3.02 WIRE MARKERS

- A. Wire markers shall be a minimum of 3/8-inches in length and placed as near as possible to the end of the wire before heat-shrinking. Orient wire marker such that the writing can be read without turning or twisting the wire.
- B. Wire numbers shall be the same at both ends of the wire.

3.03 CONDUIT MARKERS

- A. Conduit markers shall be installed near the end of each conduit run and in intermediate locations such as manholes and handholes.
- B. Attach brass conduit markers near the end of exposed conduits with 48 mil stainless steel wire (Brady Part No. 38091 or equal) and zinc wire clamps.
- C. Secure conduit markers to the floor using a permanent epoxy (Liquid Nails or equal) where conduits terminate in bell ends flush with finished floor in freestanding equipment.

****END OF SECTION****

SECTION 16450

GROUNDING

PART 1 -- GENERAL

1.01 SUMMARY

- A. Section Includes: Grounding and bonding of electrical equipment, raceways and specialized systems, including testing.

1.02 SUBMITTALS

- A. Manufacturer's data for the following:
 - 1. Connection methods
 - 2. Ground rods
 - 3. Ground rod wells
 - 4. Grounding conductors

1.03 SYSTEM DESCRIPTION

- A. Ground electrical equipment, conduits, supports, cabinets, and switchgear in accordance with NFPA 70 (NEC) and as shown on the Drawings, the intent being a system ground and an equipment ground.

1.04 QUALITY ASSURANCE

- A. Comply with the following Codes and Standards (refer to Section 16010):
 - 1. IEEE 81-1962--IEEE Recommended Guide for Measuring Ground Resistance and Potential Gradients in the Earth.
 - 2. NFPA 70 (NEC)
 - 3. NEMA
 - 4. UL listing
 - 5. MIL Handbook 419

PART 2 -- PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Ground Rods:
 - 1. Anderson Electric Corp.
 - 2. Copperweld Corp.
 - 3. Harger

2.02 MATERIALS

- A. Ground rods shall be copperclad rods $\frac{3}{4}$ -inch in diameter and 10-feet long unless indicated otherwise on the Drawings.

- B. Ground rod wells shall be 8½-inch diameter constructed of reinforced concrete with a reinforced concrete removable cover stamped “GROUND” as manufactured by Christy or equal.
- C. Connectors, mechanical lugs or wire terminals shall be used only to bond ground wires, junction and panel boxes.
- D. Grounding conductors shall be stranded copper, size as indicated on the Drawings or as required by the NEC. Grounding conductors shall be bare or contain green insulation.

PART 3 -- EXECUTION

3.01 INSTALLATION

- A. Where mechanical lugs are not welded or fastened with a threaded bolt, surfaces shall be thoroughly cleaned and paint scraped to bare metal before connections are made to insure good metal-to-metal contact.
- B. Grounding conductors shall be so installed as to permit shortest and most direct path from equipment to ground. Ground connections shall be accessible for inspection and made with approved solderless connectors braced (or bolted) to the equipment or structure to be grounded.
- C. An equipment grounding conductor must be installed in each conduit with power conductors or, in the case of multi-conductor cable, run inside the cable sheath.
- D. Whether indicated or not, the Contractor shall bond the electrical equipment pad rebar, shade structure support post and chain link fence post to the service grounding electrode system.
- E. Exterior grade mounted equipment shall have their enclosures grounded directly to the system grounding electrode conductor. This includes grade mounted luminaires.
- F. Where generators and transformers are indicated on the Drawings to be grounded, solidly ground to a separate grounding electrode located at the equipment in addition to the system ground connection. This grounding electrode shall be bonded to the system ground through the equipment grounding conductor(s) and/or a separate grounding conductor as indicated on the Drawings.
- G. A main system ground, bare copper conductors, size as indicated, shall be run in PVC conduit from the main switchgear to a ground point beyond the electrical equipment concrete pad and extended (bare conductor) to the grounding system as indicated on the Drawings.
- H. The ground system shall also be extended to metallic water piping. Provide a properly sized bonding shunt strap around the meter and dielectric unions in the water pipe unless other connection method indicated on the Drawings.
- I. Connections to ground rods and steel water piping system shall be as noted on Drawings or be exothermically welded. Ground rod connections shall be done in a ground rod well for inspection purposes.

- J. All bonds between the grounding electrode conductors and the grounding electrodes must be accessible for inspection and routine maintenance. Any buried ground connections (except for rebar bonds) will not be accepted.
- K. All enclosure doors with 120V mounted devices shall be bonded to the enclosure ground bus.

3.02 TESTING

- A. Resistance between ground and absolute earth shall not exceed 25 ohms and shall be measured using the fall of potential method with a three or four terminal ground resistance tester. The device used to perform this test must be accurate to the hundredths of an ohm. A minimum of ten (10) ground resistance tests shall be measured at 30-foot intervals from the service grounding electrode. The test results shall be plotted on a curve and submitted in the report. The ground resistance test shall be conducted by a third party, International Electrical Testing Association (NETA) accredited testing agency and shall be witnessed by the Engineer before equipment is placed in operation. Use of salts, water or compounds to attain the specified ground resistance is not acceptable, unless consulted with the Engineer for approval.
- B. Test Report: Submit grounding test report including a drawing showing locations of ground tests, date the test was conducted, the weather conditions, and the measured resistance.

****END OF SECTION****

SECTION 16475

OVERCURRENT PROTECTIVE DEVICES

PART 1 -- GENERAL

1.01 SUMMARY

- A. Section Includes: Overcurrent Protective Devices such as fuses and circuit breakers.

1.02 SUBMITTALS

- A. Fuses: Submit catalog cuts which indicate the fuse symbol and ampere rating for each disconnect or device.
 - 1. Submit manufacturer's data showing fuse name, symbol, voltage rating, UL class, interrupting capacity or I-squared time (I^2t) characteristics and accessories.
 - 2. Fuse trip curves.
- B. Breakers: Submit catalog cuts that indicate type of breaker, size, trip, characteristics, interrupting capacity, and the specified features.
- C. Overcurrent Protection Device Coordination Study: Refer to Specifications Section 16010 for requirements.

1.03 OPERATING AND MAINTENANCE MANUALS

- 1. Identify the size, model and features for each item.
- 2. Complete instructions regarding the operation and maintenance of equipment involved. Instructions and documentation not related to the equipment furnished must be removed or crossed out. *O&M manuals must be individually tailored to the project and equipment as furnished.*
- 3. Refer to Specification Section 16010 for additional requirements.

1.04 QUALITY ASSURANCE

- A. Comply with the following Codes and Standards (see Section 16010):
 - 1. NFPA 70 (NEC)
 - 2. UL listing
 - 3. ANSI
 - 4. NEMA

1.05 RELATED WORK

- A. Division 16, Electrical

PART 2 -- PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Fuses:
 - 1. Bussmann Mfg. Div.

2. Gould-Shawmut
 3. Little-Fuse
- B. Circuit Breakers:
1. Square D Co.
 2. Cutler-Hammer
 3. General Electric Co.

2.02 MATERIALS

- A. Fuses:
1. Fuses up to 600 volts shall meet the following:
 - a. Be of the same manufacturer.
 - b. Shall NOT be shipped in fused switches.
 - c. Shall be stored in a safe, moisture free area until needed.
 - d. All dual element fuses shall have separate overload and short circuit elements. The overload element shall include a spring-assisted thermal unit. The thermal unit shall open on a temperature rise above 280 degrees Fahrenheit. Time delay for the overload element shall be at least 10 seconds at 500 percent of rated amperes.
 - e. When indicated on the Drawings or required by the local authority or serving utility, fuses shall be silver-sand UL Class R or Class L. current-limiting fuses (low-peak dual element).
 - f. Motor branch circuit fuses rated 1/10 to 600 amperes shall be sized one ampere rating above the selected heater element. Fuse ampere rating shall not exceed 175 percent of motor FLA. Abnormal motor conditions requiring increased ampere ratings shall be referred to the Engineer. Fuses shall be UL Class R current-limiting dual element with time delay.
- B. Circuit Breakers:
1. Low voltage breakers up to 600 volts shall meet the following:
 - a. Be quick-make, quick-break type.
 - b. Have toggle mechanism insuring full contact pressure until time of opening whether manually or automatically operated.
 - c. Thermal magnetic type to have inverse time tripping characteristics with fixed thermal trip action to hold on harmless momentary overload.
 - d. Adjustable trip setting shall be provided for circuit breakers when necessary to obtain proper trip coordination as determined by the Overcurrent Protection Device Coordination Study.
 - e. A short circuit condition shall cause the magnetic trip element to instantly trip without damage or injury.

- f. Have non-welding, non-corroding contacts.
- g. Be full-size with mechanism enclosed in molded bake-lite case, sealed to prevent tampering or unauthorized changes in calibration.
- h. Be UL listed and recognized.
- i. Meet NEMA standards.
- j. Be bolt-on type unless otherwise specified.
- k. Have contacts that operate in a multiple plate arc-quenching chamber vented to load side of breaker - UL listed.
- l. Be rated for AIC compatible with ratings of the panel or switchboard bus they are to be used in as indicated on the Drawings. Unless otherwise indicated, series rated devices are not acceptable. All overcurrent devices shall be fully rated.
- m. Be calibrated for operation in a minimum ambient temperature of 50 degree C.
- n. All multi-pole breakers shall have common trip.
- o. For multi-pole breakers shall require the same space as the equivalent number of single pole breakers. Wafer style breakers are unacceptable.
- p. Have operating handle that visually indicates “on”, “off”, or “tripped”.
- q. Be labeled to indicate circuit number(s) and load served.
- r. be rated for 100% continuous operation where indicated on the Drawings.

PART 3 -- EXECUTION

3.01 INSTALLATION

- A. Provide overcurrent protection for all wiring and equipment in accordance with NFPA 70, State or local codes, whichever is prevailing.
- B. Should nameplate data disagree with the size or application of an overcurrent protective device indicated on the Drawings, immediately bring it to the attention of the Engineer for a decision.
- C. Place a label inside each fused switch door. Label shall indicate fuse type, ampere rating and interrupting rating. Manufacturers’ labels are acceptable.
- D. Where blank spaces or spaces designated for future overcurrent devices are indicated on the Drawings, they shall be complete with bus links.

****END OF SECTION****

SECTION 16480

MINI-POWER CENTERS

PART 1 -- GENERAL

1.01 SUMMARY

- A. Section Includes: Combination transformer/panelboard units commonly referred to by manufacturer trademark as “Mini-Power Center”.

1.02 SUBMITTALS

- A. Product Data: Provide catalog data on all components in accordance with this specification including the combination transformer/panelboard and circuit breakers contained within.
- B. Provide a panel schedule indicating each circuit breaker with load description.
- C. Provide the two-tier series rating of the mini-power center primary circuit breaker with the mini-power center branch circuit overcurrent device where the AIC on the branch circuit overcurrent device has a higher AIC rating than the mini-power center primary circuit breaker.

1.03 OPERATING AND MAINTENANCE MANUALS

- 1. Identify the size, model and features for each item.
- 2. Complete instructions regarding the operation and maintenance of equipment involved. Instructions and documentation not related to the equipment furnished must be removed or crossed out. ***O&M manuals must be individually tailored to the project and equipment as furnished.***
- 3. Complete nomenclature of replaceable parts, part numbers, current cost, name and address of nearest vendor of replacement parts. Information on equipment or components not related to equipment furnished must be removed or crossed out. ***O&M manuals must be individually tailored to the project and equipment as furnished.***
- 4. Refer to Specification Section 16010 for additional requirements.

1.04 QUALITY ASSURANCE

- A. Comply with the following Codes and Standards:
 - 1. NEMA (Testing Standards BU 1.3.03 or 1.304)
 - 2. UL listing and labeling for materials.
 - 3. NFPA-70

1.05 RELATED WORK

- A. Specification Section 16195, Identification
- B. Specification Section 16475, Overcurrent Protective Devices

PART 2 -- PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Square D Co.
- B. Cutler-Hammer
- C. Or equal

2.02 MATERIALS

- A. Mini-Power Centers shall have KVA rating as indicated on the Drawings.
- B. Mini-Power Center Units shall include integrally mounted and wired transformer primary and secondary main circuit breakers in accordance with NFPA 70 requirements.
- C. Transformer shall have 480V primary and 120/240V, 1Ø secondary as indicated on the Drawings.
- D. Transformer shall have 2-5 percent primary taps below normal. Transformer to be encapsulated in a sand-epoxy resin to protect against moisture, rust and corrosive environments.
- E. Bussing shall be copper.
- F. Branch circuit breakers shall be bolt-on type and as specified elsewhere in these specifications.
- G. Enclosures shall be cleaned, phosphatized and electrostatically powder coated and shall be UL Listed for outdoor use. A padlockable hinged access door shall be provided which maintains itself in the open position.

PART 3 -- EXECUTION

3.01 INSTALLATION

- A. Install where indicated on plans. Mount unit such that it is level and plumb.
- B. Prior to installing mini-power centers, coordinate with other trades to verify conduits have adequate space to leave and enter the tub and for required code clearance. A minimum working clearance as defined by the NEC 110-26 shall be provided.
- C. Securely fasten to wall of building or equipment rack with 3/8-inch galvanized steel bolts, nuts and lock-washers.
- D. Insert accurate panel schedule on inside of enclosure door or clearly write load description on mini-power center inner door next to each circuit breaker with a permanent black marker.
- E. Label each circuit conductor with its associated branch circuit number per Specifications Section 16195.
- F. Install nameplate on exterior of Mini-Power Center to indicate panel designation. Fasten nameplate using stainless steel self-tapping screws.

- G. Bond secondary of transformer to the service or grounding electrode system with copper grounding conductor sized as indicated on the Drawings or per NFPA 70.

****END OF SECTION****

SECTION 16481

MOTOR CONTROLLERS

PART 1 -- GENERAL

1.01 SUMMARY

- A. Section Includes: Furnish and install motor controllers as indicated on the Drawings and as specified herein.

1.02 SUBMITTALS

- A. Shop Drawings: Submit drawings which include, but not limited to, the following applicable data:
 - 1. Motor designation and horsepower
 - 2. NEMA starter sizes and overload type/sizes
 - 3. Enclosure type with interior and exterior elevations with dimensions
 - 4. Control transformer ratings
 - 5. Circuit breaker (or fuse) sizes
 - 6. Auxiliary contacts
 - 7. Control devices being utilized
 - 8. Point-to-point wiring diagram by an approved system integrator
 - 9. Bill of material including spare parts being furnished
- B. Product Data: Submit manufacturer's data showing compliance with the Drawings and these specifications.

1.03 OPERATING AND MAINTENANCE MANUALS

- A. Identify the size, model and features for each item.
- B. Complete instructions regarding the operation and maintenance of equipment involved. Instructions and documentation not related to the equipment furnished must be removed or crossed out. ***O&M manuals must be individually tailored to the project and equipment as furnished.***
- C. Complete nomenclature of replaceable parts, part numbers, current cost, name and address of nearest vendor of replacement parts. Information on equipment or components not related to equipment furnished must be removed or crossed out. ***O&M manuals must be individually tailored to the project and equipment as furnished.***
- D. Copy of warranties issued on the installation, showing dates of expiration.
- E. Refer to Specification Section 16010 for additional requirements.
- F. The O&M manuals must include a list of adjustable parameters and their as-built values for the solid state soft starter and motor protection relay.

1.04 QUALITY ASSURANCE

- A. Comply with the following Codes and Standards (see Section 16010):
 - 1. NFPA 70 (NEC)
 - 2. UL listing
 - 3. NEMA
 - 4. Horsepower application rated
 - 5. IEEE

1.05 JOB CONDITIONS

- A. Coordinate with motor manufacturer for whom starters are being furnished to verify starter selected will properly start, run and protect the motor it serves.

1.06 RELATED WORK

- A. Specification Section 16120 – Wires and Cables (600V or less)
- B. Specification Section 16195 – Electrical Identification
- C. Specification Section 16475 – Overcurrent Protective Devices

PART 2 -- PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Schneider (ALTISTART 48)
- B. No equal

2.02 GENERAL

- A. The Contractor shall furnish well pump motor controllers as detailed on the Drawings.
- B. Refer to the bill of materials provided on the Drawings for the list of components required.
- C. Motor controllers specified herein shall be suitable for use with voltage and phasing as indicated on the Drawings.

2.03 SOLID STATE REDUCED VOLTAGE TYPE

- A. The solid-state reduced voltage motor controller shall consist of a power section, a one-piece printed circuit logic board and a field wiring interface terminal board.
- B. The power section shall be three-phase, 60 hertz, and rated for the horsepower and voltage as indicated on the Drawings. It shall consist of three sets of back-to-back phase controlled power semi-conductors. Resistor/capacitor snubber networks shall be used to prevent false firing of SCR's due to dv/dt characteristics of the electrical system.
- C. Thermostatically controlled cooling fans shall be provided. Fan shroud shall penetrate the external housing for air intake and exhaust. Thermal sensors shall be provided on the heat sink to trip the control protective logic for an over-temperature condition. Thermal sensors shall be rated 90°F maximum.

- D. Overload protection shall be integral to the solid-state reduced voltage motor controller and shall be of the electronic type.
- E. Three-phase current sensing via current transformers shall be provided for closed loop control to insure motor stability.
- F. The logic circuitry shall include as a minimum:
 - 1. Inverse time running overcurrent protection.
 - 2. Auxiliary trip circuitry
 - 3. Gate firing circuit lockout protection of trip.
 - 4. Fault relay with one N.O. and one N.C. auxiliary contact.
 - 5. 250 percent - 450 percent of motor full load amp current limit adjustment.
 - 6. Minimum and maximum voltage adjustments.
 - 7. Phase sequence protection.
 - 8. Current and motor slip sensing to regulate motor voltage.
 - 9. External circuitry interface for start/stop control, run status, and common failure signals as indicated on the drawings.
 - 10. Adjustable control for controlled accelerating time (0-30 second minimum).
 - 11. Adjustable control for controlled stopping time (0-30 second minimum).
- G. Power terminations shall consist of pressure type terminals for top or bottom entrance.
- H. Short circuit withstand rating shall meet or exceed the rating of the circuit breaker feeding the solid-state starter or as indicated on the Drawings. A current limiting circuit breaker may be used to reduce the short circuit amperes to the solid-state starter.
- I. Solid-state soft starter and bypass contactor combination must be capable of operating continuously in 115°F ambient temperature conditions without air conditioning. Derate components as necessary to achieve this requirement.
- J. The solid-state soft starter shall be equipped with a backlit LCD digital operator interface/keypad that can be remote mounted on the motor controller door. The display shall be two-line, 16-characters minimum. The operator interface/keypad shall include the following features as a minimum.
 - 1. Adjustments for the following operating parameters:
 - a. acceleration ramp time (soft start)
 - b. deceleration ramp time (soft stop)
 - c. initial torque
 - d. starting current limit
 - 2. Display of the following operating parameters:
 - a. voltage
 - b. motor current

- c. KW
- d. KWH
- e. Power factor
- 3. Display of the following alarms in descriptive text:
 - a. voltage unbalance
 - b. phase reversal
 - c. undervoltage
 - d. stall
 - e. jam
 - f. overload (overcurrent)
 - g. underload (undercurrent)
 - h. excessive starts/hour
 - i. open gate (with phase indication)
 - j. controller overtemperature

2.04 NAMEPLATES

- A. Each motor controller shall be furnished with a nameplate identifying the load being served as indicated on the Single Line Diagram. Size shall be 1" x 3" minimum. See Section 16195 for additional requirements.

PART 3 -- EXECUTION

3.01 CONTROLLER FABRICATION

- A. Motor controllers shall be assembled by Schneider or by an approved UL 508A panel fabricator. The motor controller shall be provided with a serialized UL 508A label.
- B. Motor control schematics indicated on the Drawings are schematic only. They are provided for bidding purposes to show the intent of control and operation. They are not intended to be actual wiring diagrams. It is the Contractor's responsibility to ensure that all motor controllers are designed and fabricated properly to meet the intent of the Contract Documents.
- C. Control wiring shall be type MTW with red insulation (#12 minimum for power, #14 minimum for control). All control wiring shall be contained in plastic wireways with removable covers. Wiring to door mounted devices shall be wrapped in a protective plastic flex. Control wiring installed on enclosure doors shall be secured to door with wire anchors cemented in place. Each control wire shall be clearly identified with a shrink-on wire marker and wire number designation per approved wiring diagrams.
- D. All control wiring shall have heat shrinkable wire markers installed near end of wire as specified elsewhere.

- E. All field wiring shall be terminated on terminal blocks within the motor controller.
- F. Door mounted operator control devices shall be mounted a minimum of 60" above the finished grade level.

3.02 INSTALLATION

- A. Furnish and install all motor controllers as indicated on the Drawings in accordance with the NEC and all applicable industry standards.
- B. Prior to installing motor controllers, coordinate with other trades to verify conduits have adequate space to leave and enter the enclosure and for required code clearance. A minimum working clearance as defined by the NEC 110-26 shall be provided.
- C. Field-test all motor controllers to demonstrate proper operation. The motor controller fabricator shall be present during startup, testing and commissioning of each motor controller. The Engineer and/or Owner shall witness all motor controller field-testing.
- D. Set parameter in the soft starter per motor manufacturer and Engineer's recommendations.
- E. The initial setting for the motor full load amp current limit setting in the soft starter shall be 300% in the Voltage Ramp mode.
- F. Starter parameter settings shall be initially set as follows (field adjustments may be necessary):
 - 1. Low Voltage: 90% of rated motor voltage
 - 2. High Voltage: 110% of rated motor voltage
 - 3. Voltage Unbalance: 5%
 - 4. Overcurrent: Motor nameplate service factor amps
 - 5. Undercurrent: 80% of motor full load amps
 - 6. Trip Class: As recommended by motor manufacturer
 - 7. Restart Delay Adjustment: 10 seconds
 - 8. Rapid Cycle Timer: Off
 - 9. Trip Delay Adjustment: 2 seconds
 - 10. Successive Restart Attempts: 1

****END OF SECTION****

SECTION 17500

GENERAL INSTRUMENTATION

PART 1 -- GENERAL

1.01 SYSTEM DESCRIPTION

- A. This section includes the general requirements for furnishing and installing the Instrumentation, Control and Monitoring equipment as indicated on the Drawings and specified in Division 17 of these specifications. Other instrumentation and control sections of this Division shall supplement this Section as necessary.
- B. The intent of the instrumentation and control sections of Division 17 is to require that all instrumentation as indicated, specified and/or required, shall be furnished by a single competent, qualified Instrumentation and Control Subcontractor (hereinafter referred to as the I&C Contractor) to assure system compatibility and coordination with all other subsystems.
- C. The Contractor with his I&C Contractor shall provide all labor, materials, and incidentals as indicated, specified and required to furnish, install, calibrate, adjust, test, document, start-up and train for a complete, integrated and functionally operational Instrumentation and Control System as is intended by these Contract Documents. The system includes but is not necessarily limited to the following major equipment:
 - 1. RTU and Radio Telemetry System programming
 - 2. Field Instruments
- D. The Contractor shall be responsible for coordination of the installation, programming, SCADA computer graphics modifications, onsite startup and testing of the RTU/telemetry system with the Engineer and NTUA. The Contractor shall also be responsible of coordination of the installation, onsite startup and testing of the RTU with the Engineer and NTUA.
- E. Labor, materials, apparatus, and components essential to the complete functioning of systems described and indicated herein, or which may be reasonably implied as essential, whether mentioned in the Contract Documents or not, shall be furnished and installed by the Contractor. In case of doubt as to the work intended, or in the event of need for explanation thereof, the Contractor shall refer to the Engineer for supplemental instructions.
- F. All items not specifically mentioned in these specifications or noted on the Drawings, or on shop drawings, but which are necessary to make a complete and satisfactory, working electrical/instrumentation installation, shall be deemed to be included herein. The Construction Documents are not intended to show every fitting, junction, or component nor every difficulty that may be encountered during installation or coordination with different equipment manufacturers. The Contractor shall refer to related data in all Contract Documents and shall verify this information on site.

- G. Unless otherwise indicated, all equipment and components shall be rated for use in the environment installed. Outdoor equipment shall be weatherproof or rated for outdoor use. Equipment installed in corrosive areas shall be rated for that environment. In case of doubt as to the area classification, or need for explanation thereof, or discrepancies noted between components specified and the environment installed the Contractor shall consult with the Engineer for supplemental instructions.
- H. RTU's and PLC's shall be programmed by the Owner. The Contractor shall coordinate the installation, wiring and programming of the RTU's and PLC's with the Engineer and Owner, as well as make provisions for on site startup and testing of the equipment.

1.02 SUBMITTALS

- A. Submit number of copies as specified elsewhere in these specifications. If not specified elsewhere, submit minimum of six (6) copies. Refer to individual Specification Sections for products requiring submission.
- B. Submit Division 17 in one submittal, or at a maximum, the following may be submitted as separate submittals for this project.
 - 1. Section 17510 – Field Instruments
 - 2. Sections 17520, 17530/17531
- C. Documentation must be arranged in numerical sequence corresponding with each Specification Section and article of each Section. Soft copies shall be in “pdf” format with “character recognition” and shall include the following as a minimum:
 - 1. A cover sheet to identify the Contractor's name, name of the project, date and description, i.e. “Division 17 – Field Instruments”.
 - 2. An index corresponding to each specification section with all addendum updates included. Each paragraph or bulleted item shall be check marked to signify compliance with each item and the information is included in the submittal package. If full compliance is not met for any reason, the non-compliance item shall be underlined and reference to a detailed written explanation of the deviation or non-compliance shall be provided in the margin to the right of the specification paragraph or bulleted item for consideration.
 - 3. Bookmarks within each section for each major component within.
 - 4. Complete manufacturer name and model number of each item. Listing items “as specified” without both make and model or type designation is not acceptable.
 - 5. Descriptive Data: Submit copies of complete descriptive literature, performance data, physical dimensions, power and signal connections for each component and equipment to be furnished. Provide name of manufacturer, style, and complete model number. Listing items “as

specified” without both make and model or type designation is not acceptable.

6. Component Data Sheets: Submit a component data sheet for each piece of instrumentation equipment similar to an ISA S20 form. Include equipment tag number, manufacturer’s model number, location of service, materials of construction, size and scale range, calibrated range, setpoints, optional accessories and any other useful information.
- D. Hard copies, if required, shall be bound in 3-ring binders (2” max) and include all information as described above for soft copies. The binders shall include tabs corresponding to a neatly typewritten index. The binder cover and edge shall clearly identify the Contractor’s name, name of the project, date and identified as “Instrumentation O&M Manual”.
- E. Important Notice:
1. **After material or equipment has been submitted and approved, no substitutions will be allowed. Any equipment installed that is different than the approved shop drawings and submittals will be removed and replaced at the Contractor’s expense without exception!**
 2. If Contractor's submittal(s) depart from the Contract Documents, the Contractor shall make specific mention thereof in his letter(s) of transmittal, otherwise review of such submittals by the Engineer shall not constitute review of such departure(s).
 3. The Contractor may be charged for costs incurred by the Engineer for third and subsequent submittal reviews. Cost for Engineer’s review time shall be billed at the Engineer’s standard hourly rates.
 4. Where calculations, sealed by a registered professional engineer, are required to be submitted, they will be reviewed for content and format but will not be reviewed for accuracy.
- F. Control Panel Drawings: Submit 11” X 17” detailed shop drawings with interior and exterior elevations with dimensions, component layout, mounting details, point-to-point wiring diagrams, nameplate legends and bill of materials prepared by a UL 508A recognized system integrator.
1. Wiring diagrams shall include all interconnections, inter-wiring and terminals between all electrical and/or instrumentation units. Wire numbers shall be continuous from start to finish. Wire numbers shall not change when going from one unit, cabinet, enclosure, terminal or any device to another.
 2. Discrete control and power circuits: Submit ladder diagrams indicating all panel devices related to discrete functions mounted in or on control panel. Show unique rung numbers on left side of each rung. Label each wire, coil and terminal block. Show individual component terminal numbers.
 3. Analog signals: Indicate the entire analog loop on the wiring diagram including all devices connected in series and location of each device.

Indicate loop power supplies and individual component terminal numbers. Indicate wire and terminal numbers of each device in the loop.

4. Use different symbols for terminal blocks located in different pieces of equipment. Label each terminal block and wire termination point.
5. If applicable, show each PLC I/O point rack, slot, terminal number and PLC configured address on each drawing.
6. Submit a block diagram of the distributed control and monitoring system network.

1.03 OPERATING AND MAINTENANCE MANUALS

A. Operating and Maintenance Manuals (O&M): The Contractor shall provide O&M manuals for equipment and materials furnished under this contract. Submit number of copies as specified in Division 1 of these specifications (min 4). Information shall be assembled in individual indexed volumes identifying the size, model, and features indicated for each item. Each copy shall include the following information as a minimum:

1. 3-ring binders (2-inch max) and include tabs and neatly typewritten index. The binder cover and edge shall be identified as "Instrumentation O&M Manual" and shall include the date and name of the project.
2. Identify the size, model, and features for each piece of equipment.
3. Complete instructions regarding the installation, operation and maintenance of equipment involved. Instructions and documentation not related to the equipment furnished must be removed or crossed out. ***O&M manuals must be individually tailored to the project and equipment as furnished.***
4. Bill of Materials, component data sheets, descriptive literature, product specification sheets, wiring diagrams and calibration procedures. ***O&M manuals must be individually tailored to the project and equipment as furnished.***
5. Complete nomenclature of replaceable parts, part numbers, current cost, name and address of nearest vendor of replacement parts. Information on equipment or components not related to equipment furnished must be removed or crossed out. ***O&M manuals must be individually tailored to the project and equipment as furnished.***
6. Copy of warranties issued on the installation, showing dates of expiration.
7. Provide a copy of all instrument calibration reports.
8. Soft copy shall be on a CD, "pdf" format – including "character recognition", and shall include all information provided in hard copy. CD's must be properly labeled with the following as a minimum: Facility Name, Project Title and Title of Manual.

1.04 OPERATION AND MAINTENANCE DATA

- A. As-built wiring diagrams showing connections to all devices; input and output, analog and discrete. Include a complete Bill of Materials indicating each system component by model number.

1.05 RECORD DRAWINGS

- A. Record Drawings: Upon completion of work, Contractor shall furnish a complete set of Record Drawings and Shop Drawings which properly reflect final tested system, loop diagrams, PLC programs, etc., as actually installed. Drawings shall accurately record the final constructed system and shall be labeled as “RECORD”.

1.06 REFERENCES

- A. The specifications reference known standards and codes. Each such standard referenced shall be considered a part of the Specifications to the same extent as if reproduced therein in full. The following is a representative list of such Associations, Institutes and Societies, together with the acronym by which each is identified.

AIEE	American Institute of Electrical Engineers
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
ICEA	Insulated Cable Engineers Association
IEEE	Institute of Electrical and Electronics Engineers
NEC	National Electrical Code (2005)
NEMA	National Electrical Manufacturers Association
NETA	National Electrical Testing Association
NFPA	National Fire Protection Association
UL	Underwriter’s Laboratories, Inc.

- B. Every reference in the Specifications shall mean the latest printed edition of each in effect at the Contract date or latest edition as adopted by the local governing authority.

1.07 SYSTEM RESPONSIBILITY

- A. The I&C Contractor shall have total responsibility for the work as specified in the instrumentation and control specifications of this Division of these Specifications. This includes but is not necessarily limited to furnishing system components, system integration and design, wiring diagrams, loop drawings, installation supervision, field instrument calibration, start-up, testing and operator training.
- B. The I&C Contractor is a Subcontractor. Therefore, references made to the responsibilities and requirements of the I&C Contractor shall only mean that the responsibilities and requirements pass through the I&C Contractor but the final responsibility rests with the Contractor.

1.08 QUALITY ASSURANCE

- A. The I&C Contractor shall be a reputable system integrator and be an Underwriters Laboratory (UL) 508A recognized panel fabricator. The I&C Contractor must be

located within a 500 mile radius of the project and have been in that vicinity for a minimum of five (5) years.

- B. The I&C Contractor must have a minimum of five (5) years experience as a system integrator, panel fabricator and instrumentation supplier for other projects of similar type, size and requirements. The Contractor must submit documentation from his selected I&C Contractor verifying the experience and UL 508A file number.
- C. All equipment furnished shall be new and of current design. Like equipment shall be of the same manufacturer.

1.09 COORDINATION

- A. The I&C Contractor shall coordinate with all other equipment manufacturers to avoid conflicts and interferences. No extra compensation will be allowed for changes made necessary due to conflicts between various equipment.
- B. Any discrepancies noted in these contract documents or discrepancies between Drawings and actual field conditions shall be promptly brought to the Engineer for a decision. No extra compensation will be allowed for changes made by the Contractor without Engineer's consent.
- C. The Contractor shall be responsible for coordination of control panel fabrication, testing and instrumentation system installation with configuration of the PLC, radio modem and operator interface. Project completion will not be granted to the Contractor until programming and configuration has been completed and complete automatic operation has been tested.

1.10 WARRANTY

- A. In addition to specific warranties required by the Specifications, the Contractor shall leave the entire installation in complete working order and free from defects in materials, workmanship or finish. Contractor shall repair or replace at his own expense any part that may develop defects due to faulty material or workmanship during the tests and within a period of one year (minimum, or as indicated elsewhere) after final acceptance. The Contractor shall repair or replace existing equipment and work that is damaged during the repair of defective apparatus, materials or workmanship at no cost to the Owner.
- B. All manufacturer's warranties shall be filled out in their entirety by the I&C Contractor for the Owner using the Owner's name and address. Equipment warranty periods will commence on date of final acceptance.

PART 2 -- PRODUCTS

2.01 STANDARD EQUIPMENT

- A. Unless a specific product by manufacturer and model number has been called out, furnish and install equipment of the type specified which has been proven to operate successfully. Material or equipment that has been specified or called out

by manufacturer and/or model number must be supplied with **no substitute**. All other equipment may be selected based on equal quality and performance.

- B. All control panel components shall be UL recognized or ground fault protected per UL 508A fabrication standards. Each control panel assembly shall bear a serialized UL 508A label.
- C. All instrumentation equipment and control panel components shall be capable of operating successfully at full-rated load, without failure, at an ambient air temperature of 50°C, and specifically rated for the altitude in which the equipment will be placed in service.

2.02 SPARE PARTS AND ACCESSORIES

- A. Furnish any special tool required for maintenance or routine calibration of equipment.
- B. Refer to individual Sections within this Division for required spare parts.

PART 3 -- EXECUTION

3.01 FACTORY ACCEPTANCE TEST (FAT)

- A. Before delivering any control panels to the site, the I&C Contractor shall notify the Engineer in writing at least two weeks prior so that a factory acceptance test can be performed. The test shall be conducted only after the I&C Contractor and Owner have performed their programming, operator interface configuration, testing and functional checkout of the system including PLC logic. The PLC and operator interface programs shall be thoroughly tested. Each input and output signal shall be tested for proper indication and control function.
- B. The factory acceptance test shall be conducted by the I&C Contractor with the Programmer present. The test shall be witnessed by the Engineer.
- C. A successful factory acceptance test only allows the I&C Contractor to ship the system to the site. It does not constitute final acceptance by the Owner.

3.02 INSTALLATION SUPERVISION

- A. The I&C Contractor shall furnish the services of instrumentation technicians or control system engineers trained and experienced in the installation of the various instrument and control equipment being supplied. These services shall be utilized by the Contractor as he deems necessary to supervise installation, calibrate, troubleshoot and put equipment into service.

3.03 INSTRUMENT CALIBRATION

- A. The I&C Contractor shall provide the services of a factory representative with the proper tools and equipment to properly calibrate and adjust each instrument in the field. The Engineer shall be notified when the factory representative will be onsite to witness instrumentation calibration and setup. This site visit by the factory representative may also be utilized for the Owner designated operator training as required below.

- B. Each instrument shall be tested with certified test instruments simulating inputs at 0, 25, 50, 75 and 100 percent of the calibrated range. Ten (10) data points shall be recorded by ascending to 100 percent then descending back to 0. Data shall be recorded on a prepared Instrument Calibration Report with the following information:
1. Instrument description
 2. Type and location of service
 3. Manufacturer, model and serial number of instrument
 4. Scale range and engineering units
 5. Testing method and description
 6. Input values or settings
 7. Output values (recorded data)
 8. Calibrations notes or explanations
 9. Technician's name, date and signature
 10. Copy of the test instrument calibration report. Testing instrument must have been calibrated within one year prior to calibration date.

3.04 START-UP AND COMMISSIONING

- A. Upon completion of installation, the Contractor shall test the control system for proper operation after making final connections. After the Contractor has successfully started up and tested all system components, the start-up and testing shall be performed again with the City and the Engineer present.
- B. The Contractor shall notify the Engineer and City in writing when he considers the system is complete and in good working order for scheduling the start-up and testing date. If retesting is required, the Contractor shall follow this same procedure.

3.05 FINAL ACCEPTANCE

- A. Upon completion of instrument calibration and system validation, all systems to be retested under process conditions. The Owner, Engineer and Contractor shall perform this test as a final acceptance test for each instrument or piece of equipment. The process variables will be pushed to their limit to verify accuracy, alarms and interlocks. Any defects or problems will be corrected immediately. Once all testing has been completed to the Owner's satisfaction, the I&C Contractor shall submit a certified report with all substantiating data sheets indicating that the total instrumentation and control system meets the functional intent of the Contract Documents.
- B. After installation of the system and checkout by the Owner, Engineer and Contractor, a 30-day acceptance test shall be performed. The 30-day acceptance test shall include an operational demonstration of at least 30 days during which the system shall run continuously without loss of basic functions. The operational demonstration shall confirm that the status, alarm, and process variable signals are valid and are being updated appropriately. During the operational demonstration,

the Owner shall record all errors or abnormal occurrences. The Contractor shall investigate the problems and log his observations including a description of the problem, its apparent cause, and the action taken, if any, to recover from the occurrence. Repeated failure of any hardware component shall cause the acceptance test to be terminated and restarted.

3.06 OPERATOR TRAINING

- A. The I&C Contractor shall provide factory trained personnel for each field instrument to perform Owner designated operator training of each system. The training shall be done in a group session for a minimum of 1 day or may be incorporated during calibration and setup as described above. The training shall cover the basic system operation, calibrations, adjustments, routine maintenance and repair.

****END OF SECTION****

SECTION 17510
FIELD INSTRUMENTS

PART 1 -- GENERAL

1.01 SYSTEM DESCRIPTION

- A. This section includes the general requirements for furnishing and installing the field instruments as indicated on the Drawings and specified in this Division of these specifications. Other instrumentation and control sections of this Division shall supplement this Section as necessary.
- B. The Contractor with the I&C Contractor shall provide all labor, materials, and incidentals as indicated, specified and required to furnish, install, calibrate, adjust, test, document, start-up and train for each field instrument furnished.
- C. Labor, materials, apparatus, and components essential to the complete functioning of field instruments described and indicated herein, or which may be reasonably implied as essential, whether mentioned in the Contract Documents or not, shall be furnished and installed by the Contractor. In case of doubt as to the work intended, or in the event of need for explanation thereof, the Contractor shall refer to the Engineer for supplemental instructions.
- D. For purposes of clarity and legibility, the Drawings are diagrammatic only. Construction Documents are not intended to show every fitting, junction, or component nor every difficulty that may be encountered during installation or coordination with different equipment manufacturers. The Contractor shall refer to related data in all Contract Documents and shall verify this information on site.

1.02 SUBMITTALS

- A. Descriptive Data: Submit copies of complete descriptive literature, performance data, physical dimensions, power and signal connections for each field instrument to be furnished. Provide name of manufacturer, style, and complete model number. Listing items "as specified" without both make and model or type designation is not acceptable.
- B. Component Data Sheets: Submit a component data sheet for each piece of instrumentation equipment similar to an ISA S20 form. Include equipment tag number, manufacturer's model number, location of service, materials of construction, size and scale range, calibrated range, setpoints, optional accessories and any other useful information.
- C. Submit drawings and bill of materials for any sun shields that may be required. Drawings must clearly indicate how the sun shield will be fabricated and mounted.
- D. Submit instrument tags including a list of designations and instrument numbers to be indicated on each tag.

1.03 OPERATING AND MAINTENANCE MANUALS

- A. Installation requirements and procedures.
- B. Complete instructions regarding the operation and maintenance of equipment involved. Instructions and documentation not related to the equipment furnished must be removed or crossed out. *O&M manuals must be individually tailored to the project and equipment as furnished.*
- C. Bill of Materials, descriptive literature, wiring diagrams and calibration procedures. *O&M manuals must be individually tailored to the project and equipment as furnished.*
- D. Component data sheets, product specification sheets and calibration procedures from the approved submittals shall be included.
- E. Complete nomenclature of replaceable parts, part numbers, current cost, name and address of nearest vendor of replacement parts. Information on equipment or components not related to equipment furnished must be removed or crossed out. *O&M manuals must be individually tailored to the project and equipment as furnished.*
- F. Provide a copy of all instrument calibration reports.
- G. Refer to Specification Section 17500 for additional requirements.

1.04 COORDINATION

- A. The Contractor shall coordinate with all other equipment manufacturers and trades to avoid conflicts and interferences. No extra compensation will be allowed for changes made necessary due to conflicts between various equipment.
- B. Any discrepancies noted in these contract documents or discrepancies between Drawings and actual field conditions shall be promptly brought to the Engineer for a decision. No extra compensation will be allowed for changes made by the Contractor without Engineers consent.

1.05 IDENTIFICATION TAGS

- A. All field instruments shall have an identification tag meeting the following requirements:
 - 1. 19 gauge, 2-inch square stainless steel (Brady Part No. 44403 or equal)
 - 2. Device designation **and** field instrument number shall be permanently etched or embossed onto the stainless steel tag with engraved, black-filled, 1/4-inch Arial font lettering.
 - 3. Device designation and instrument number on tag shall be as indicated on the Drawings.
 - 4. Tags shall be fastened to the instrument housing with stainless steel rivets, self tapping screws or with 48 mil stainless steel wire (Brady Part No. 38091 or equal) and zinc wire clamps.
 - 5. Identification tags must be installed on **all** field instruments whether provided by a vendor as part of a packaged system or not.

PART 2 -- PRODUCTS

2.01 SUBMERSIBLE LEVEL TRANSDUCER

- A. Submersible level transducers shall consist of an all-titanium housing and removable polyurethane nose specifically designed for liquid level measurement. The transducer shall contain a silicon piezoresistive pressure sensor that converts the applied pressure, performs linearization, temperature correction, atmospheric pressure correction, damping, and other transfer functions to determine the correct value of the applied pressure. The applied pressure shall be converted to a 4-20mA DC signal. The level transducer shall have the following functions and features as a minimum:
1. Range: as required for the maximum process liquid level
 2. Over Range: 4X rated psi minimum
 3. Accuracy: 0.25% full scale
 4. Operating Temperature Range: -5°F to +140°F
 5. Compensated Temperature Range: +30°F to +86°F
 6. Temperature Effect: less than 1.5% full scale
 7. Dimensions: 8" long x 0.75" diameter maximum
 8. Moisture Protection:
 9. Temp: -20°C to 80°C
- B. An 8"x8"x4" NEMA 3R enclosure shall be provided to house the termination enclosure furnished with the submersible level transmitter. The termination enclosure shall include reusable desiccant cartridges or other low maintenance alternative to prevent moisture from entering and condensing in the vent tube. The surge protection kit shall include a factory-installed unit at the cable end of the transducer housing as well as a DIN rail mounted unit. The transducer and analog signal cables shall terminate in this enclosure.
- C. A polyurethane cable molded to the transducer shall be furnished with sufficient length to reach the sensor termination enclosure without splicing. The cable shall include a vent tube that allows for pressure adjustments due to atmospheric pressure.
- D. One manufacturer's portable pressure calibrator shall be furnished with the submersible level transducer(s).
- E. The Contractor shall furnish and install all mounting hardware and support structures for the transducer and termination enclosure as required for proper operation and in accordance with the manufacturer's recommendations and meets the intent of the Contract Documents. Materials used for support structures shall be suitable for the environment in which it is installed (corrosive - stainless steel, non corrosive - galvanized steel; unless indicated otherwise).
- F. Acceptable Manufacturers:
1. Druck

2. Endress+Hauser
3. KPSI/Measurement Specialties
4. Or equal

2.02 CONDUCTIVITY PROBES

- A. Unless otherwise indicated or required for the application, electrodes shall be ANSI Type 316 stainless steel suspended type (except probes contained within a probe bottle and less than six feet in length may be the solid rod type) with a PVC outer sheath and electrode holders shall contain an ANSI Class 125 flange or external pipe flange. Electrodes shall be furnished with cable of sufficient length to facilitate proper operation.
- B. A mating flange, pipe, etc. shall be installed as necessary to properly mount the probe holder and provide easy access for maintenance. Probe holder shall be weatherproof, rated for outdoor use.
- C. Electrode relays shall be solid-state, octal plug-in type with two SPDT output contacts rated not less than 5 amps at 120 VAC. The relay shall contain an LED status indication, increasing/decreasing time delay functions (5-seconds, unless otherwise indicated) and integral surge protection. The relay coil power shall be 120 VAC, 60 Hz, single phase. Intrinsically safe solid-state relays shall be utilized whenever the electrodes are located in a hazardous or explosion-proof classified area.
- D. Electrodes and conductance relays shall be:
 1. Warrick Controls
 2. B/W Controls
 3. Or equal

2.03 PRESSURE GAUGES

- A. Pressure gages shall have the following features as a minimum:
 1. Housing: 4-1/2", aluminum case with glass lens, white dial and black numbers/graduations/pointer
 2. Silicone oil filled
 3. Range: 0 – 100 psi
 4. Proof pressure: 150 percent of range psi minimum
 5. Accuracy: one percent of full scale
 6. Wetted material: 316 stainless steel
 7. Dial/pointer: stainless steel or aluminum
 8. Service: liquid, gas, or vapors as indicated on the Drawings
 9. Process connection: 1/4" NPT male
 10. Calibration: micro-adjustment screw
 11. Accessories: test cock, female outlets and an isolation ball valve

- B. An isolation ball valve shall be furnished and installed on each pressure gauge for ease of removal without disruption of service. The valve shall be sized as required for the process connection.
- C. A diaphragm seal with flushing connection shall be furnished and installed to isolate each pressure gauge installed with a process connection other than potable water or clean air.
- D. The Contractor shall furnish and install all mounting hardware and support structures necessary for proper operation in accordance with the manufacturer's recommendations and the Contract Documents. Materials used for support structures shall be suitable for the environment in which it is installed (corrosive - stainless steel, non corrosive - galvanized steel; unless indicated otherwise).
- E. Acceptable Manufacturers:
 - 1. US Gauge (Ametek)
 - 2. Ashcroft
 - 3. Winters
 - 4. Or equal

2.04 PRESSURE SWITCHES

- A. Pressure switches shall be of the snap-action, switch actuated, Bourdon tube type with a visible calibrated dial and pointer(s) indicating switch setting(s). Function shall be for gauge pressure, external field adjustable with a trip point repeatability of 1% of actual pressure. Pressure switches shall have the following features and functions as a minimum:
 - 1. Housing: NEMA 4 except where mounted in a separate enclosure
 - 2. Range: As indicated on the Drawings or as required for the application
 - 3. Proof pressure: 150 percent of range psi minimum
 - 4. Actuating element: Single point service - 316 SS Bourdon tube
Dual point service - 304 SS Bourdon tube
 - 5. Electrical switch: Mercury switch, SPDT, 120VAC, 10A min except for potable water applications, which shall utilize snap-action type switch, SPDT, 120VAC, 10A min
 - 6. Service: liquid, gas, or vapors
 - 7. Process connection: 1/4" N.P.T. male
- B. An isolation ball valve, union and "T" fitting with plug shall be furnished and installed on each pressure switch for ease of removal and calibration without disruption of service. The valve and fittings shall be sized as required for the process connection.
- C. A diaphragm seal with flushing connection shall be furnished and installed to isolate each pressure switch installed with a process connection other than potable water or clean air.

- D. The Contractor shall furnish and install all mounting hardware and support structures necessary for proper operation in accordance with the manufacturer's recommendations and the Contract Documents. Materials used for support structures shall be suitable for the environment in which it is installed (corrosive - stainless steel, non corrosive - galvanized steel; unless indicated otherwise).
- E. Where indicated on Drawings or as required for dual control, pressure switches shall have an adjustable deadband for setting separate open and close operating pressures. Minimum adjustable deadband setting shall be no greater than 20 psi.
- F. Acceptable Manufacturers:
 - 1. Mercoid, DA/DS series
 - 2. Or equal

2.05 GAUGE PRESSURE TRANSMITTERS

- A. The pressure sensor shall utilize oil filled sensing diaphragms with capacitor plates that convert the applied pressure to an electronic signal to the transmitter logic unit. The transmitter logic unit shall be solid state, programmable micro-processor based electronic unit that receives the capacitor signals and performs linearization, temperature correction, rangedown, damping, and other transfer functions to determine the correct value of the applied pressure. The transmitter shall be 2-wire and provide a proportional 4-20mA dc signal and shall provide an integral digital display. The pressure transmitter assembly shall be suitable for sensing gauge, absolute, or differential type pressures as specified herein and/or as indicated of the Drawings. The pressure transmitter assembly shall have the following functions and features as a minimum:
 - 1. Microprocessor based software that can perform self-diagnostics and provide a communications port utilizing a recognized industry standard type protocol.
 - 2. Integral indicator to display process pressure in engineering units.
 - 3. Integral pushbuttons for local programming, including digital trimming of sensor and output electronics with zero and span adjustments.
 - 4. Range: 0 - 300 PSI, unless noted otherwise.
 - 5. Rangeability: 15:1
 - 6. Service: liquid, gas, or vapors.
 - 7. Analog output: 2-wire, 4-20mA(selectable for linear or square root)
 - 8. Operating temperature of logic unit: -40 to 85 deg C.
 - 9. Operating temperature of sensor (silicone fill): -40 to 104 deg C.
 - 10. Humidity limits: 0 to 100% relative
 - 11. Damping: 0 to 16 sec (adjustable in 0.1 sec steps)
 - 12. Accuracy: +/- 0.1% of calibrated spans from 1:1 to 10:1 with a repeatability of 0.1%
 - 13. Stability: +/- 0.25%

14. Temperature effect at max span: zero error: +/- 0.2% per 56 deg C, total effect +/- 0.38% of span per 56 deg C.
 15. Temperature effect at min span: zero error: +/- 3% per 56 deg C, total effect +/- 3.18% of span per 56 deg C.
 16. Wetted materials: Isolating diaphragm: 316L SS; Drain/vent valves: 316 SS; Process flange and adapters: 316 SS; O-rings: Viton.
 17. Non-wetted materials: Fill fluid: Silicone oil; Bolts: Cadmium-plated carbon steel; Electronics housing: Low-copper aluminum - NEMA 4X; Cover O-rings: Buna-N; Paint: Epoxy-polyester.
 18. Process connections: 1/2"-14 NPT, unless indicated otherwise on Mechanical Plans.
 19. Electrical connections: 1/2"-14 NPT conduit with screw terminals and integral test jack plugs compatible with miniature banana plugs.
- B. A stainless steel block and bleed valve shall be furnished and installed on each pressure transmitter for ease of calibration and service. The block and bleed valve shall be sized as required for the process connection.
- C. A diaphragm seal with flushing connection shall be furnished and installed to isolate each pressure transmitter installed with a process connection other than potable water or clean air.
- D. The Contractor shall furnish and install all mounting hardware and support structures necessary for proper operation in accordance with the manufacturer's recommendations and the Contract Documents. Materials used for support structures shall be suitable for the environment in which it is installed (corrosive - stainless steel, non-corrosive - galvanized steel; unless indicated otherwise).
- E. Acceptable Manufacturers:
1. Endress Hauser PMC71
 2. Foxboro, Model IGP10
 3. Or equal

2.06 SURFACE MOUNTED INTRUSION ALARM SWITCHES

- A. Intrusion alarm switches for gates and doors shall be a heavy-duty industrial, adjustable magnetic wide gap type. Switch and magnet housing shall be constructed of anodized aluminum.
- B. Door, gate and cabinet intrusion alarm switches shall be provided with an armored flexible cable and wiring assembly of sufficient length to reach junction/termination box indicated on the Drawings without splicing.
1. Acceptable Manufacturers:
 - a. G.E. Sentrol Model 2507AH
 - b. Or equal

PART 3 -- EXECUTION

3.01 INSTALLATION

- A. Inspect each instrument and piece of equipment for defects, damage and correct operation before installation. Inspect work area and work involving other trades to verify readiness for installation.
- B. Field instruments shall be installed per manufacturer's requirements. Verify that all mounting, process and electrical connections are secure and tight before operating instrument.
- C. Install field instrument identification tag as described above.
- D. The Contractor shall coordinate with the Mechanical Contractor to verify process connection type and location.
- E. Field instruments installed in hazardous (classified) locations shall be installed in approved enclosures or electrically connected through an intrinsically safe barrier and shall meet all other requirements of NFPA 70 Articles 500-503.
- F. Furnish and install sun shields for all analog instruments installed outdoors in direct sunlight where recommended by the instrument manufacturer.
- G. Refer to Section 17500 for additional installation supervision, calibration, testing and start-up requirements.

****END OF SECTION****

SECTION 17520

LOCAL CONTROL PANELS

PART 1 -- GENERAL

1.01 SUMMARY

- A. The I&C Contractor shall furnish all tools, equipment, materials, and supplies, and shall perform all labor as required for furnishing and installing Local Control Panel (LCP's) as indicated on the Drawings and as specified herein or in other Sections of the Specifications. Local control panels (LCP's) shall be designed to provide functionality and control as intended.
- B. The following is a list of LCP's to be furnished under this Specification Section:
 - 1. Remote Terminal Unit (RTU)

1.02 SUBMITTALS

- A. Submit shop drawings in accordance with Section 17500.
- B. Product Data: Submit manufacturer's data demonstrating compliance with specification requirements. Including enclosure, finish, control devices, relays, terminal blocks, wireway and accessories.
- C. Product Data: Submit manufacturer's data demonstrating compliance with specification requirements. Including control devices, light kit, exhaust fan, surge arrester, receptacles, UPS, Ethernet switch, control relays, pilot lights, terminal blocks, DIN rails, plastic raceway and accessories.
- D. Submit LCP wiring diagrams showing each and every wire in the panel and field wiring to the panel including each wire number and wire size. The wiring diagrams must indicate the terminal number at each device or terminal block where the wire is terminated, including field devices.
- E. Submit interior component layout drawings of LCP's with component labels and bill of materials.
- F. Submit exterior elevation drawings of LCP's with dimensions and device labels.
- G. PLC/RTU cabinet wiring diagrams shall indicate wiring for each PLC input/output (I/O), including spare I/O. The wiring diagrams shall also indicate the I/O address point to be used in the PLC program.
- H. Submit a block diagram of the distributed control and monitoring system network.
- I. UPS: Submit UPS load calculations as described herein.
- J. Power supplies: Submit load calculations with documentation indicating load of each component deriving power from the power supply to show that the total connected load does not exceed 50% of the power supply's capacity.

1.03 OPERATING AND MAINTENANCE MANUALS

- A. Installation requirements and procedures.

- B. Complete instructions regarding the operation and maintenance of equipment involved. Instructions and documentation not related to the equipment furnished must be removed or crossed out. *O&M manuals must be individually tailored to the project and equipment as furnished.*
- C. Bill of Materials, component data sheets, descriptive literature, product specification sheets, wiring diagrams and calibration procedures. *O&M manuals must be individually tailored to the project and equipment as furnished.*
- D. Complete nomenclature of replaceable parts, part numbers, current cost, name and address of nearest vendor of replacement parts. Information on equipment or components not related to equipment furnished must be removed or crossed out. *O&M manuals must be individually tailored to the project and equipment as furnished.*
- E. Refer to Specification Section 17500 for additional requirements.

1.04 QUALITY ASSURANCE

- A. Equipment shall be designed and installed to conform to Drawings, Specifications, Engineering data, related equipment furnished by other suppliers and recommendations of the RTU manufacturer.
- B. Design, construct and test according to the following Codes and Standards:
 - 1. NEMA ICS-1, 2 & 3
 - 2. NEMA (Testing Standards BU 1.3.03 or 1.304)
 - 3. UL listing and labeling for materials.
 - 4. NFPA-70
 - 5. UL 508A

1.05 CONSTRUCTION STANDARDS

- A. Each LCP shall be fabricated by a UL 508A recognized panel assembler and contain a serialized UL-508A label. All control panel components shall be UL Listed or UL Recognized under the category “Industrial Control Equipment”.

1.06 RELATED WORK

- A. Specification Section 17500 - General Instrumentation
- B. Specification Section 17520 – Local Control Panels
- C. Specification Section 17520 – NTUA Standard PLC Control Panel
- D. Specification Section 17531 – Remote Terminal Unit (RTU)

PART 2 -- PRODUCTS

2.01 GENERAL

- A. The I&C Contractor shall furnish the LCP(s) to satisfy the functional requirements specified in the relevant mechanical equipment, and Instrumentation & Control specification sections and as indicated on the Drawings. All components shall be

UL labeled or provided with proper ground fault protection as required by UL 508A.

- B. LCP enclosures shall be as indicated or described on the Drawings. Enclosures located outdoors shall be NEMA 3R and enclosures located indoors shall be NEMA 12, unless otherwise indicated. Each LCP enclosure shall contain a full size, steel back panel painted white for mounting components. LCP enclosures shall be ANSI 61 gray, unless otherwise indicated. LCP enclosures shall be steel with hinged doors. Freestanding enclosures shall have a 3-point latching handle. Outdoor enclosures with panel mounted devices shall contain a white interior swing panel.

2.02 TERMINAL BLOCKS

- A. Each LCP shall be provided with identified terminal strips for the connection of all external conductors. There shall be sufficient terminal blocks for all external connections plus an additional 25 percent spare for future use. Terminal blocks shall be identified in accordance with approved shop drawings. Terminal blocks shall be individual, stacking, compression type, 600VAC, 30A minimum, suitable for wire sizes No. 10 - No. 18. A printed terminal block label shall be affixed to each terminal block for identification.
- B. Each field-mounted device deriving power from the LCP shall be individually protected with a circuit breaker (Phoenix Contact TMC 1-M1 with N/C output contact) or fused terminal block (knife-blade or plug-in fuse) with blown fuse indicator.
- C. Terminal blocks for analog signals shall be tiered style with built-in 3-stage surge protection for connection of a twisted shielded pair conductor including a separate ground connection. Analog signal terminal blocks shall be Phoenix Contact model TT-2PE-24DC or equal.

2.03 OPERATOR DEVICES

- A. Pushbuttons, selector switches, and pilot lights shall be of the heavy-duty, oil-tight type, 30mm in size. Miniature style devices are not acceptable.
- B. Pilot lights shall be push-to-test, LED style with LED and lens color as indicated on the Drawings.
- C. START buttons shall have green cap and STOP buttons shall have red caps. All other button caps and selector switch operator handles shall be black. Pushbutton caps and selector switch operator handles shall be black.
- D. Selector switches shall have the number of positions as indicated on the Drawings or as required to perform the intended function. Provide the number of 120VAC, 10A contacts as indicated on the Drawings or as required to perform the intended function.
- E. Provide an engraved legend plate or provide laminated plastic nameplates as specified elsewhere for each device.

- F. The operator devices shall have a NEMA rating equal to or more stringent than the control panel in which it is mounted.
- G. Acceptable manufacturers:
 - 1. Cutler-Hammer 10250 series
 - 2. Square D 9001SK series
 - 3. Or equal

2.04 CONTROL RELAYS

- A. Control relays shall be DPDT (minimum) plug-in type utilizing rectangular blades with an indicating LED, and sockets with screw-type terminals and hold-down clips. Operating coil voltage shall be as required or indicated on the Drawings.
- B. Contacts shall be rated 10 Amps at 120 VAC. Contact material shall be silver-cadmium oxide except for signal switching circuits that shall be gold plated or other noble metal.
- C. Acceptable manufacturers
 - 1. Square D Type K
 - 2. IDEC Type RH
 - 3. Or equal

2.05 TIMING RELAYS

- A. Time delay relays shall be a combination on-delay and off-delay (selectable) with adjustable timing range from 1 sec to 10 hours. The timing relays shall include an LED indicator that is illuminated when the relay is timing out. Operating coil voltage rating shall be as indicated on the Drawings with DPDT, 120VAC, 10 amp rated contacts. Provide sockets with screw-type terminals and hold-down clips.
- B. Reset Timers: Reset timers shall be synchronous motor driven with a solenoid-operated clutch. The timing relays shall include an LED indicator that is illuminated when the relay is timing out. Voltage rating shall be as indicated on the Drawings with 120VAC, 10-amp rated contacts, and timing range as required or indicated on the Drawings.
- C. Acceptable manufacturers:
 - 1. ATC
 - 2. IDEC
 - 3. Or equal

2.06 SURGE PROTECTIVE DEVICES

- A. A 120VAC surge protective device (SPD) shall be installed on the 120V panel power supply as indicated on the Drawings.

- B. The SPD unit shall be NEMA 4X rated, UL 1449 Third Edition Listed, pre-wired with conductor leads a minimum of 24-inches in length and contain LED indicator lights to indicate power is applied to the SPD and all is OK (Green).
- C. The SPD unit shall be ANSI/IEEE C62.11, C62.41, C62.45 categories A, B, C3 tested.
- D. Surge Current Capacity shall be 50kA minimum.
- E. The SPD unit shall provide protection for all possible modes (L-N, L-G, N-G). Voltage Protection Rating (VPR) shall be 600V for 120VAC.
- F. Warranty shall be for a minimum period of two years.
- G. Acceptable manufacturers:
 - 1. Emerson
 - 2. Advanced Protection Technologies
 - 3. Or equal

2.07 POWER SUPPLIES

- A. Power supplies shall be DIN-rail mounted and be of the solid-state circuitry type UL-1950 and CSA-1402C certified. Input power shall be 120VAC, $\pm 10\%$, output voltage shall be as indicated on the Drawings or as required for proper operation of connected loads.
- B. Power supplies shall be sized for 200% of the total connected load.
- C. Line regulation shall be within ± 0.05 percent with a 10 percent line change. Load regulation shall be within ± 0.05 percent with a 50 percent load change. Output ripple shall not exceed 0.2 percent peak-to-peak. Transient response shall be less than 50 microseconds for a 50 percent load change.
- D. Power supplies shall be fully rated with an efficiency of at least 60 percent for a temperature range of 0 - 60°C or be oversized appropriately. Power supplies shall produce EMI/RFI noise levels within the requirements of FCC Docket 20780.
- E. Power supplies shall contain internal short circuit and overload protection. Output fusing shall be supplied on the positive terminal.
- F. Acceptable manufacturers:
 - 1. Phoenix Contact Quint
 - 2. No Equal

2.08 UNINTERRUPTIBLE POWER SUPPLY (UPS)

- A. The UPS unit shall consist of a microprocessor controlled UPS control module and sealed, maintenance free, lead-acid batteries with automatic bypass switching upon input supply failure.
- B. The UPS control module shall include built-in rectifier/battery charger, static transfer switch, and solid-state controls to provide a true sine-wave output. The UPS control module shall be housed in a rugged industrial grade enclosure.

- C. Input voltage range: 22.5-30VDC.
- D. Output power: 22.5-30VDC, 20A. Actual output rating of each UPS shall be as required to operate all loads being served for a minimum of 10 minutes without input power. UPS load calculations must be submitted with the UPS for approval.
- E. UPS control module ambient temperature range: 0 - 60°C
- F. Batteries shall be sealed, maintenance-free type, designed for 5 years minimum service.
- G. The UPS control module shall contain status LED's displaying the following as a minimum: UPS ready/buffering, UPS fault and low battery.
- H. UPS shall be provided with dry contacts that close upon low battery alarm and input power loss.
- I. The UPS control module shall be provided with a 2-year (minimum) warranty.
- J. Acceptable manufacturers:
 - 1. Phoenix Contact Mini Power
 - 2. No Equal

2.09 TEMPERATURE SWITCHES

- A. A temperature switch shall be provided for each RTU cabinet. Each switch shall be provided with a set of normally open, dry contacts that will close when room or enclosure temperature rises to the preset temperature. Each temperature switch shall be provided with an adjustable temperature range of 60 to 120 degrees Fahrenheit. Contact ratings shall be 5A minimum.

2.10 CABINET LIGHT AND RECEPTACLE

- A. The RTU Cabinet shall be supplied with a 15A GFCI type convenience receptacle and single tube, fluorescent cabinet light with protective lamp shield. The cabinet light shall be controlled by a door activated switch that closes when the control panel door (inner door) is opened.

2.11 SPARE PARTS

- A. Provide a minimum of 10 spare lamps.
- B. Provide one control and one timing relay of each type utilized.
- C. Provide one spare power supply of each size and type utilized.
- D. Provide (3) spare fuses of each size and type utilized.
- E. Refer to related specification sections for additional spare parts required.

PART 3 -- EXECUTION

3.01 FABRICATION

- A. Each PLC I/O point connected to an external device shall be terminated at terminal blocks. Where AC and DC signals must intercept each other, cross wires

at 90° angles. Route AC and DC signals in separate wireways. Provide blank wireways for field wiring by the Contractor.

- B. All internal wiring shall be contained in plastic raceways or troughs having removable covers. Wiring to door-mounted devices shall be extra flexible and anchored to doors using wire anchors cemented in place. Exposed terminals of door-mounted devices shall be guarded to prevent accidental contact with energized terminals.
- C. Control panel conductors shall be stranded copper with 600V type MTW insulation. Minimum control panel conductor size for power shall be No.12 AWG. Minimum conductor size for control wiring shall be No. 14 unless protected by a 10A overcurrent protective device or smaller, in which case it can be No.16 AWG. Analog signal cables shall be 600V, No.16 AWG twisted shielded pair.
- D. All conductors shall be labeled. Wire markers shall be heat shrinkable, be a minimum of 3/8-inches in length and placed as near as possible to the end of the wire. Orient wire marker such that the writing can be read without turning or twisting the wire.
- E. Identification of panel-mounted devices control equipment enclosure shall be engraved laminated plastic with black letters on white background. Use minimum 3/16-inch letters for identifying individual panel components. Use minimum 3/8-inch letters for identifying control equipment enclosure.
- F. LCP enclosure doors that contain 120VAC devices shall be bonded to the enclosure grounding lug.
- G. All analog signals shall be individually fused at the terminal block. See additional requirements as specified elsewhere in these specifications.

3.02 INSTALLATION

- A. LCP(s) shall be installed as indicated on the drawings. All front accessible panel-mounted devices shall be mounted a minimum of 42-inches above finished floor elevation.
- B. LCP(s) shall be stored in an indoor, dry location at the jobsite to protect from condensation, damage, and the effects of weather.
- C. LCP(s) interiors, and exteriors shall be cleaned, and coatings shall be touched up to match original finish upon completion of the work.
- D. See Section 17500 for additional installation requirements.

3.03 TESTING, STARTUP & TRAINING

- A. LCP's shall be assembled and tested at the control panel shop for sequence of operation prior to jobsite delivery. An additional test shall be performed on site after all field wiring and external devices have been installed and connected. Coordinate with the Owner for PLC Programming and operator interface configuration installation.

- B. Before LCP's can be shipped to the jobsite, a factory acceptance test must be successfully conducted at the control panel shop in the presence of the Engineer and Owner. The factory acceptance test will only be conducted after the PLC programming and operator interface configuration have been completed.
- C. See additional testing, start-up and training requirements as specified elsewhere in these specifications.

SECTION 17530

PROGRAMMABLE LOGIC CONTROLLERS (PLC)

PART 1 -- GENERAL

1.01 SUMMARY

- A. This section includes the furnishing and installation of a Programmable Logic Controller (PLC) for the remote terminal unit (RTU) consisting of a PLC, operator interface terminal (OIT), power supplies, interconnecting cables and all associated components for control and monitoring of equipment as indicated on the Drawings and as specified herein.
- B. The Contractor shall coordinate the installation and wiring of each PLC with the I&C Contractor, Owner, Engineer, and make provisions for on-site start-up and testing of the PLC's.

1.02 SUBMITTALS

- A. Manufacturer's catalog cut sheets indicating electrical characteristics, capabilities and physical attributes for each PLC component including PLC, OIT, CPU, power supplies, I/O modules, special interface modules or devices, module racks, interconnecting cables and any other equipment related to the PLC.
- B. A tabular list must be submitted for all discrete and analog I/O which will include:
 - 1. Rack number, module number, module I/O point number.
 - 2. Name of each I/O field device.
 - 3. Instrument tag number of the I/O device located in the contract documents.
 - 4. Electrical characteristics of I/O signal.
 - 5. PLC internal address.
- C. Include a list of I/O being monitored and controlled from any human-machine interface (HMI) such as an OIT and/or SCADA computer.

1.03 OPERATING AND MAINTENANCE MANUALS

- A. Installation requirements and procedures.
- B. Complete instructions regarding the operation and maintenance of equipment involved. Instructions and documentation not related to the equipment furnished must be removed or crossed out. ***O&M manuals must be individually tailored to the project and equipment as furnished.***
- C. Bill of Materials, component data sheets, descriptive literature, product specification sheets, wiring diagrams and calibration procedures. ***O&M manuals must be individually tailored to the project and equipment as furnished.***
- D. Complete nomenclature of replaceable parts, part numbers, current cost, name and address of nearest vendor of replacement parts. Information on equipment or

components not related to equipment furnished must be removed or crossed out.
O&M manuals must be individually tailored to the project and equipment as furnished.

- E. Refer to Specification Section 17500 for additional requirements.

1.04 QUALITY ASSURANCE

- A. Equipment shall be designed and installed to conform to Drawings, Specifications, Engineering data, related equipment furnished by other suppliers and recommendations of the RTU manufacturer.
- B. Design, construct and test according to the following Codes and Standards:
 - 1. NEMA ICS-1, 2 & 3
 - 2. UL 508A
 - 3. NFPA-70.

1.05 RELATED WORK

- A. Specification Section 17500 - General Instrumentation
- B. Specification Section 17520 - Local Control Panels

1.06 SYSTEM OVERVIEW

- A. Remote telemetry unit PLC's with their associated components provide logic for monitoring and control of the water treatment systems as indicated on the Drawings and as described in these Specifications.

PART 2 -- PRODUCTS

2.01 PROGRAMMABLE LOGIC CONTROLLER

- A. General
 - 1. The PLC(s) shall be furnished with hardware, software, cables, connectors, adapters, operation and maintenance manuals necessary to monitor and control equipment as intended by these Construction Documents.
- B. PLC Programming Software
 - 1. The PLC programming software shall enable the user to write the PLC program in on-line or off-line modes.
 - 2. The software shall include utilities to manage PLC program files, document and print the programs, configure the programming environment, monitor and force the PLC addresses while on-line, and configure the PLC memory and addressing structure.
 - 3. One copy of the PLC programming software shall be provided with the user's manuals, original diskettes, and licensing agreement for registration by the Owner.
- C. Central Processing Unit (CPU)

1. The CPU shall be a microprocessor based industrial controller with a temperature rating of 0 to 60 degrees C and a humidity rating of 0 to 95 percent non-condensing, minimum.
2. Memory (RAM) shall be sized as required for all system logic and control functions with a minimum of 50 percent spare capacity. RAM shall be protected by lithium battery backup for at least one year, and capacitor storage for up to two weeks.
3. The CPU shall be programmable using conventional ladder-type and function block logic.
4. The CPU shall be able to perform the following functions:
 - a. Data comparisons
 - b. On-delay and Off-delay Timers
 - c. Counters
 - d. Master Control Relays
 - e. Transitional or one-shot outputs
 - f. PID loop control
 - g. Floating point math
5. The CPU shall be provided with internal fault analysis with a fail-safe mode and output for remote failure alarming. A minimum of two communication ports shall be provided on the CPU. One port shall be utilized for a peer-to-peer network connection as indicated on the Plans. A second communication port shall be used for connection to an Operator's interface or other peripheral devices as indicated on the Drawings.

D. Communication Modules

1. Furnish PLC with communication module(s) as required to communicate with other peripheral devices as indicated on the Drawings.

E. I/O Modules

1. Each field input and output shown as an I/O point shall be connected per the manufacturer's requirements and recommendations.
2. The I/O module chassis shall include a minimum of 20% blank back panel space for future I/O modules. Each empty slot shall be provided with an empty slot filler card. PLC rack shall include the appropriate end caps.
3. Discrete input modules shall be plug-in, rack style modules with 24V DC rated inputs and shall have LED indicators for each point displaying the status of the field contact. A maximum of sixteen (16) isolated dry contact type discrete inputs shall be provided per module. Provide a minimum of 20 percent spare points wired to terminal blocks.
4. Discrete output modules shall be plug-in, rack style modules with a source voltage output having a current rating of 0.5A at 24V DC, minimum. Outputs shall have LED indicators for each output status. Each output shall drive an interposing relay with DPDT contacts rated 10A at 120 VAC. A maximum of sixteen (16) isolated dry contact type discrete

outputs shall be provided per module. Provide a minimum of 10 percent spare points complete, wired to interposing relays and terminal blocks.

5. Analog input modules shall be plug-in, rack style modules which will accept 4-20Ma DC signals. Input circuitry shall provide differential input (no common) to prevent loop grounding problems. Analog to digital conversion shall have 12 bit resolution or greater. A maximum of eight (8) isolated analog inputs shall be provided per module. Provide a minimum of 10 percent spare points wired to terminal blocks.
6. Analog output modules shall be plug-in, rack style modules which transmit isolated linear 4-20Ma DC signals to field devices. Loop power for analog outputs shall be provided by regulated power supplies each capable of driving a 0-600 Ohm load. Digital to analog conversion shall have 12 bit resolution or greater. A maximum of eight (8) isolated analog outputs shall be provided per module. Provide a minimum of 10 percent spare points wired to terminal blocks.

F. PLC Power Supply

1. The PLC power supply shall be rack mounted and shall be of the same manufacturer as the PLC.
2. The PLC power supply shall be sized as required with an additional 50% spare capacity. Power supply calculations shall be furnished to verify power supply rating selected.

G. Acceptable Manufacturers

1. Modicon M340
2. No equal

2.02 OPERATOR INTERFACE TERMINAL (OIT)

- A. The OIT shall include a communication port for connection to the PLC as indicated on the Drawings.
- B. The operator interface shall be furnished with hardware, cables, software, operation and maintenance manuals as necessary.
- C. Acceptable Manufacturers
 1. Schneider Magelis GTO
 2. No equal

2.03 NETWORKING COMPONENTS

- A. Ethernet Switch
 1. Five 10/100Base TX RJ-45 ports.
 2. Fully IEEE 802.1 compliant.
 3. Auto detecting 10BaseT/100BaseTX, Duplex, MDIX.
 4. Fully managed.
 5. Mounting: DIN rail.

6. Power: 24VDC
7. UL listed.
8. Acceptable manufacturers:
 - a. Phoenix Contact FL SWITCH SFN
 - b. Or equal

2.04 SPARE PARTS

- A. Provide one spare PLC power supply.
- B. Provide one spare PLC CPU.
- C. Provide one spare I/O module of each type utilized.

PART 3 -- EXECUTION

3.01 INSTALLATION

- A. The PLC's shall be installed as indicated on the Drawings and in accordance with the manufacturer's recommendations and requirements. Each PLC I/O point connected to an external device shall be terminated at terminal blocks. Where AC and DC signals must intercept each other, cross wires at 90 degree angles. Route AC and DC signals in separate wireways. Provide blank wireways for field wiring by the Contractor.
- B. All analog input and output signals shall be individually fused at the terminal block. See additional requirements as specified elsewhere in these specifications.
- C. Upon completion of installation, start-up shall be performed by the I&C Contractor and witnessed by the Engineer and/or Owner. See additional requirements as specified elsewhere in these specifications.
- D. The PLC program, operator interface graphical screens and I/O shall be thoroughly tested. Each input and output signal shall be tested for correct indication and control function. The Contractor shall coordinate with the Owner for PLC programming and operator interface configuration installation. See additional requirements as specified elsewhere in these specifications.
- E. Managed Ethernet switches shall be fully configured.

****END OF SECTION****

SECTION 17531

REMOTE TERMINAL UNIT (RTU)

PART 1 -- GENERAL

1.01 SUMMARY

- A. This section includes the furnishing and installation of a Remote Terminal Unit (RTU) consisting of a Programmable Logic Controller (PLC), operator interface terminal (OIT), radio modem, antenna, antenna mast, power supplies, interconnecting cables and all associated components for control and monitoring of equipment per NTUA standards and as specified herein.
- B. The Contractor shall coordinate the installation and wiring of the RTU with the I&C Contractor, Engineer, and make provisions for on-site start-up and testing of the RTU.

1.02 SUBMITTALS

- A. Manufacturer's catalog cut sheets indicating electrical characteristics, capabilities and physical attributes for each RTU component including PLC, OIT, CPU, power supplies, I/O modules, special interface modules or devices, module racks, radio modem, antenna, antenna mast, interconnecting cables and any other equipment related to the RTU.
- B. A tabular list must be submitted for all discrete and analog I/O which will include:
 - 1. Rack number, module number, module I/O point number.
 - 2. Name of each I/O field device.
 - 3. Instrument tag number of the I/O device located in the contract documents.
 - 4. Electrical characteristics of I/O signal.
 - 5. PLC internal address.

Include a list of I/O being monitored and controlled from the operator interface terminal (OIT) and/or SCADA computer.

1.03 OPERATING AND MAINTENANCE MANUALS

- A. Installation requirements and procedures.
- B. Complete instructions regarding the operation and maintenance of equipment involved. Instructions and documentation not related to the equipment furnished must be removed or crossed out. ***O&M manuals must be individually tailored to the project and equipment as furnished.***
- C. Bill of Materials, component data sheets, descriptive literature, product specification sheets, wiring diagrams and calibration procedures. ***O&M manuals must be individually tailored to the project and equipment as furnished.***

- D. Complete nomenclature of replaceable parts, part numbers, current cost, name and address of nearest vendor of replacement parts. Information on equipment or components not related to equipment furnished must be removed or crossed out. *O&M manuals must be individually tailored to the project and equipment as furnished.*
- E. Refer to Specification Section 17500 for additional requirements.

1.04 QUALITY ASSURANCE

- A. Equipment shall be designed and installed to conform to Drawings, Specifications, Engineering data, related equipment furnished by other suppliers and recommendations of the RTU manufacturer.
- B. Design, construct and test according to the following Codes and Standards:
 - 1. NEMA ICS-1, 2 & 3
 - 2. UL 508A
 - 3. NFPA-70.

1.05 RELATED WORK

- A. Specification Section 17500 - General Instrumentation
- B. Specification Section 17520 – Local Control Panels
- C. Specification Section 17520 – NTUA Standard PLC Control Panel

1.06 SYSTEM OVERVIEW

- A. The RTU with its associated components provide logic for monitoring and control of the system as indicated on the Drawings and as described in these Specifications.

PART 2 -- PRODUCTS

2.01 RTU CABINET

2.02 PROGRAMMABLE LOGIC CONTROLLER

- A. General
 - 1. The PLC(s) shall be furnished with hardware, software, cables, connectors, adapters, operation and maintenance manuals necessary to monitor and control equipment as intended by these Construction Documents.
- B. PLC Programming Software
 - 1. The PLC programming software shall enable the user to write the PLC program in on-line or off-line modes.
 - 2. The software shall include utilities to manage PLC program files, document and print the programs, configure the programming environment, monitor and force the PLC addresses while on-line, and configure the PLC memory and addressing structure.

3. One copy of the PLC programming software shall be provided with the user's manuals, original diskettes, and licensing agreement registered in the Owner's name.
- C. Central Processing Unit (CPU)
1. The CPU shall be an Modicon model M340.
 2. Memory (RAM) shall be sized as required for all system logic and control functions with a minimum of 50 percent spare capacity. RAM shall be protected by lithium battery backup for at least one year, and capacitor storage for up to two weeks.
 3. A minimum of two Modbus TCP/IP communication ports and one USB programming port shall be provided on the CPU.
- D. Communication Modules
1. Furnish PLC with communication module(s) as required to communicate with other peripheral devices as indicated on the Drawings.
- E. I/O Modules
1. Each field input and output shown as an I/O point shall be connected per the manufacturer's requirements and recommendations.
 2. Discrete input modules shall comply with the module specified in the NTUA Standard PLC Control Panel. Provide a minimum of 20 percent spare points wired to terminal blocks.
 3. Discrete output modules shall comply with the module specified in the NTUA Standard PLC Control Panel. Provide a minimum of 10 percent spare points complete, wired to interposing relays and terminal blocks.
 4. Analog input modules shall comply with the module specified in the NTUA Standard PLC Control Panel. Provide a minimum of 10 percent spare points wired to terminal blocks.
 5. Analog output modules shall comply with the module specified in the NTUA Standard PLC Control Panel. Provide a minimum of 10 percent spare points wired to terminal blocks.
- F. PLC Power Supply
1. The PLC power supply shall be rack mounted and shall be of the same manufacturer as the PLC.
 2. The PLC power supply shall be sized as required with an additional 50% spare capacity. Power supply calculations shall be furnished to verify power supply rating selected.
 3. Refer to the NTUA Standard PLC Control Panel for additional power supply requirements.

2.03 OPERATOR INTERFACE TERMINAL (OIT)

- A. The OIT shall be a Schneider Magelis GTO

- B. The OIT shall include a communication port for connection to the PLC as indicated on the Drawings.
- C. The operator interface shall be furnished with hardware, cables, software, operation and maintenance manuals as necessary.
- D. A minimum of five (5) graphic screens shall be developed to display and control the system I/O as indicated on the Drawings and described in Section 17550.
 - 1. The displays shall be reviewed during the submittal review process and again during startup and testing. If modifications are deemed necessary by the Engineer, the Contractor shall make modifications at no cost to the Owner.
- E. Refer to the NTUA Standard PLC Control Panel for additional information.

2.04 ETHERNET SWITCH

- A. The make and model of the Ethernet switch shall be Phoenix Contact FL SWITCH SFN. The total number of ports shall be a minimum of five (5) 10/100Base TX RJ-45 ports.
- B. Refer to the NTUA Standard PLC Control Panel for additional information.

2.05 RADIO TELEMETRY COMPONENTS

- A. The make and model of the 900-928 Mhz radio modem shall be GE MDS Orbit or TransNet with DIN rail mounting kit.
- B. Antenna mast and grounding as indicated on the Drawings.
- C. Stainless steel antenna mounting hardware as required for mounting to the antenna mast.
- D. 900MHz Wireless RTU components shall be Phoenix Contact Radioline or equal.
- E. Polyphaser IS-50NX-C2 antenna feedline surge suppressor.
- F. Andrew LDF4-50A ½” antenna feedline.
- G. Andrew 241088-1 grounding strap and weatherproofing kit for ½” antenna feedline.
- H. Refer to the NTUA Standard PLC Control Panel for additional information.

2.06 SPARE PARTS

- A. Provide one spare CPU.
- B. Provide one spare PLC power supply.
- C. Provide one spare I/O module of each type utilized.
- D. Provide one spare communication module of each type utilized.

PART 3 -- EXECUTION

3.01 INSTALLATION

- A. The RTU shall be installed as indicated on the Drawings and in accordance with the manufacturer's recommendations and requirements. Each PLC I/O point connected to an external device shall be terminated at terminal blocks. Where AC and DC signals must intercept each other, cross wires at 90 degree angles. Route AC and DC signals in separate wireways. Provide blank wireways for field wiring by the Contractor.
- B. All spare I/O shall be wired to terminal blocks for future use. Spare discrete output points shall be wired to interposing relays and then to the terminal blocks.
- C. All analog input and output signals shall be individually fused at the terminal block. See additional requirements as specified elsewhere in these specifications.
- D. Install a copper grounding conductor with green insulation between antenna grounding kit and ground system as indicated on the Drawings. Provide exothermic weld for each ground connection.
- E. Install antenna mast and antenna as indicated on the Drawings.
- F. Upon completion of installation and all field wires terminated, the Contractor shall thoroughly test the RTU for proper operation with all field wiring terminated. Each input and output signal shall be tested for correct indication and control function. When the Contractor is satisfied that the system performs as intended by these Contract Documents, the Contractor shall call for an official start-up. System start-up shall be performed by the Contractor with the I&C Contractor and Programmer present and witnessed by the Engineer and/or Owner. See additional requirements as specified elsewhere in these specifications.
- G. Coordinate with the Owner for establishing communication with the existing reservoir site.

3.02 TRAINING

- A. There are no training requirements for this item.

****END OF SECTION****

SECTION 17550

CONTROL DESCRIPTIONS

PART 3 GENERAL

3.09 GENERAL SCOPE OF WORK

- A. This section includes the general system overview and description of logic for each piece of equipment being controlled by the PLC and/or operator interface terminal (OIT). Other sections of Division 17 shall supplement this Section as necessary.
- B. The intent of this section is to provide guidance to the Contractor and programmer as to the intended logical function or purpose of various I/O signals indicated on the Drawings. The control and monitoring functions described herein cover the basic intent for each I/O signal and operational function for outputs. The primary function of these control descriptions is to provide the Contractor with information that cannot be indicated in electrical schematic diagrams such as logic performed by a PLC or the OIT.
- C. An attempt has been made on the Drawings and in these Specifications to describe system logic and functionality as well as show all signals, interlocks, and devices necessary for proper operation of the control and monitoring systems. However, if a particular signal, device, sensor, interposing control relay, signal converter, control logic, interlock (hardware or software), etc., is required to meet the intent or operational requirements and is not indicated, the programmer shall furnish and install this piece of equipment or programming logic with no extra compensation.
- D. PLC programming and OIT configuration shall be provided by the Contractor to perform monitoring and control as indicated in these Contract Documents and as intended for a fully operational system. The Contractor shall coordinate the fabrication, installation, programming and testing of the entire control system. The Contractor shall coordinate the fabrication, installation, programming and testing of the entire control system with the Programmer and I&C Contractor.
- E. The Contractor is responsible for subcontracting the services of a Programmer for programming the PLC, configuring the OIT and establishing communication between each remote well site and the existing storage reservoir site. All costs for the Programmer shall be included in the Contractor's bid.

3.03 DELIVERABLES

- A OIT/PLC cross-reference table/interface list. The cross-reference list shall include all PLC registers linked to the OIT. The list shall include the OIT tag, PLC address, I/O type and range of analog signals in engineering units.
- B The final PLC program after final acceptance of the project with detailed descriptions for each programming logic sub-section. The detailed control

descriptions for each program sub-section shall be done to the satisfaction of the Engineer.

- C The final OIT graphic configuration files after final acceptance of the project.

PART 4 PRODUCTS (NOT USED)

PART 5 EXECUTION

5.09 OIT GRAPHIC CONFIGURATION

- A The Programmer shall create graphical screens on the OIT at the RTU to display and provide control/monitoring features as indicated on the Drawings and as described herein. See Attachment A for OIT screens shots of existing Well Site screens.
- B The Engineer shall review the OIT graphic screens during the submittal review stage and again during startup and system demonstration. If *minor* modifications are deemed necessary or requested by the Engineer or Owner during the startup, the Programmer shall make the modifications at no additional cost.

5.10 WELL PUMP CONTROL

Well Pump to supply water to the refurbished raw water storage tank located in the raw water room located in the water treatment plant building. The Well Pump is hard wired to the RTU for monitoring and start/stop control. The RTU utilizes the raw water tank level and operator adjustable setpoints to start and stop the Well Pump.

Manual operation: In Hand mode, the well pump will run continuously until the H-O-A is turned to the OFF position. Well pump in hand and running status shall be sent to the PLC/RTU.

Automatic operation: In Auto mode, the well pump is controlled by the treatment plant RTU based on level in the raw water storage tank. Well pump in auto status shall be sent to the PLC/RTU.

Interlocks/alarms: If the well pump is called to start and a RUN status signal has not been received by the PLC within 60-seconds, a well pump failure alarm shall be activated on the OIT. This alarm must be reset from the OIT before the well pump can be called to start again.

A normally open contact activates (closes) on the controller when the controller is powered up deactivates (opens) when a fault is detected. Soft start fault status shall be sent to the PLC/OIT and displayed on the OIT. The soft start fault will be activated on the controller and an alarm displayed on the OIT until the manually reset from the OIT.

When the Soft Starter reaches the end of ramp up a contact closes and energizes a definite purpose contactor, this contactor signals the a "Run Status" to the RTU and energizes the Raw Water Chlorine Pump Receptacle.

A soft start current output shall be sent to the PLC/RTU and displayed on the OIT. The current output signal will only be active when the pump is running.

An undercurrent alarm setting on the well pump controller shall be provided to prevent the pump from running if water level in the well falls too low or if the well is pumped against a closed valve. A low-level condition on the well will shutdown the pump and display an alarm on the OIT until manually reset from the OIT.

An overcurrent alarm setting on the well pump controller shall be provided to prevent the pump from running higher current than programmed in the controller. An overcurrent will shut down the pump and display an alarm on the OIT until it is manually reset from the OIT.

Refer to the P&ID for minimum status and alarm signals to be monitored and displayed for each well pump.

3.03 RAW WATER STORAGE TANK LEVEL CONTROL

The storage tank water level shall be monitored with the use of a submersible level transducer that sends a 4-20mA signal to the PLC proportional to tank level. If the level transducer signal fails (signal falls to zero, open loop or out of range), an alarm shall be displayed on the operator interface. *Level transmitter failure is not indicated on the Plans.* The level signal shall be recorded (historical trending) on the OIT Screen.

If tank level rises above or falls below operator adjustable tank warning setpoints, a high or low-level warning shall be displayed on the operator interface. The warning shall remain active until the tank level gets back to an acceptable level (somewhere between the high and low warning setpoints) and has been reset from the operator interface.

Storage tank high-high and low-low level alarm signals come from backup level probes. Each alarm shall be displayed on the operator interface. The alarms will remain active until manually reset at the operator interface and level in the storage tank returns to normal (level somewhere between the high-high and low-low level probes). A high-level alarm shall disable the well pump until the alarm has been reset. A low-level alarm condition shall disable all raw water booster pumps and the RO System until the alarm has been reset.

3.04 RAW WATER DUPLEX BOOSTER PUMP SKID (PACKAGED)

The raw water booster pumps will pull water from the raw water storage tank and deliver water to the RO System. The raw water booster pump control panel is hard wired to the RTU for monitoring and start/stop control. Each raw water pump will be controlled by a variable frequency drive (VFD). The VFD's will be used for soft-starting only. The speed will not be varied. Pumps will run at a constant pre-selected speed.

Manual operation: In Hand mode, a booster pump will run continuously until the HOA is turned to the OFF position. Booster pump running status shall be sent to the PLC/RTU accordingly.

Automatic operation: In Auto mode, an In-Auto status signal shall be sent to the PLC/RTU and displayed on the operator interface. With the HOA in the auto mode, the booster pump will be controlled by the PLC/RTU. The booster pump will be started and stopped based on level in the finished water clearwell. When the finished water clearwell

level is low, a call for water will be sent to the RO skid MCP via Ethernet from the RTU. A raw water booster pump will be called to start by the RO skid MCP via Ethernet communication back to the RTU. A discrete output from the RTU will start and stop one raw water booster pump at a time. Alternation will be done with PLC logic. Both pumps will never run at the same time. Booster pump in auto status shall be sent to the PLC/RTU accordingly.

Interlocks/alarms: If a raw water pump is called to start and a RUN status signal has not been received by the PLC within 60-seconds, a raw water booster pump failure alarm shall be activated on the OIT. Once the alarm is activated the RTU will call for the standby pump to start. This alarm must be reset from the OIT before the initial booster pump can be called to start again.

A booster pump fault status shall be sent to the PLC/OIT and displayed on the OIT. The booster pump fault will be displayed on the OIT until manually reset from the OIT.

If the raw water storage tank low-low level alarm is activated, the raw water booster pumps will be disabled. The alarm will remain active and pumps disabled until manually reset at the operator interface and level in the storage tank returns to normal.

3.05 RO SYSTEM MAIN CONTROL PANEL (Packaged)

In addition to the ethernet communication cable (Modbus TCP/IP), two hardwired alarms will be sent to the RO System MCP to shut down the treatment system in an emergency.

- 1) Finished Water Clearwell High Level Alarm
- 2) Raw Water Storage Tank Low Level Alarm

Adedge shall provide a list of signals that can be monitored from their PLC in the RO Skid MCP via Ethernet. The signals available for monitoring will be sent to NTUA for selection.

3.06 FINISHED WATER PUMP CONTROL PANEL

The finished water pumps will pump water from the clearwell to the remote distribution storage tanks No. 1 and No. 2. The finished water pump control panel is hard wired to the RTU for monitoring and start/stop control. The RTU receives the distribution storage tank level via a pressure/level transmitter installed on the discharge header of the finished water pumps.

Remote distribution storage tanks No. 1 and No. 2 levels shall be indicated and recorded on the operator interface. The finished water pumps start/stop level setpoints shall be operator adjustable and indicated on the operator interface.

Manual operation: In Hand mode, a booster pump will run continuously until the H-O-A is turned to the OFF position. Booster pump running status shall be sent to the PLC/RTU accordingly.

Automatic operation: In Auto mode, an In-Auto status signal shall be sent to the PLC/RTU and displayed on the operator interface. With the HOA in auto mode, the booster pump will be started and stopped based on the level of the storage tanks. When the level in the storage tanks is low, a call for water will be sent to the finished water

pump control panel via hard wired signal from the RTU. A discrete output from the RTU will start and stop one finished water pump at a time. Alternation will be done with PLC logic. Both pumps will never run at the same time. Finished water pump in auto status shall be sent to the PLC/RTU accordingly.

Interlocks/alarms: If a finished water pump is called to start and a RUN status signal has not been received by the PLC within 60-seconds, a finished water pump failure alarm shall be activated on the OIT. Once the alarm is activated the RTU will call for the standby pump to start. This alarm must be reset from the OIT before the initial finished water pump can be called to start again.

A finished water pump fault status shall be sent to the PLC/OIT and displayed on the OIT. The finished water pump fault will be displayed on the OIT until manually reset from the OIT.

If the finished water clearwell low-low level alarm is activated, a low-level alarm shall be displayed on the operator interface and the finished water booster pumps will be disabled. The alarm will remain active and pumps disabled until manually reset at the operator interface and level in the clearwell returns to normal.

If the finished water clearwell high-high level alarm is activated, a high-level alarm shall be displayed on the operator interface and the RO System will be disabled.

3.07 DISTRIBUTION STORAGE TANK LEVEL MONITORING

The distribution storage tank water level shall be monitored by one pressure transmitter that sends a 4-20mA signal to the RTU/PLC proportional to distribution storage tank level measured in PSI. The pressure transmitter shall be calibrated and programmed to read in PSI and the RTU/PLC shall be programmed to translate the PSI reading to a level reading. The distribution storage tank level shall be displayed and trended on the OIT. If the pressure transmitter signal fails (signal falls to zero or open loop), an alarm shall be displayed on the OIT and an alarm activated.

If the distribution storage tank level rises above or falls below operator adjustable distribution storage tank alarm setpoints, a high or low-level alarm shall be displayed on the OIT. The alarm shall remain active until the distribution storage tank level gets back to an acceptable level (somewhere between the high and low alarm setpoints) and has been reset from the OIT.

A high-level alarm condition shall shutdown the finished water pumps when the finished water pumps are in Auto mode as selected from the finished water pump control panel. Each finished water pump shall remain stopped until the level in the distribution storage tanks falls to the appropriate start level setpoint for the pumps.

3.08 INTRUSION ALARMS

There are several intrusion alarm switches being monitored by the PLC/RTU, one at each treatment building entrance door. When a door is opened, an alarm shall be displayed on the operator interface. The alarm display shall remain active until manually reset or acknowledged from the operator interface.

3.09 UPS LOW BATTERY ALARM

An uninterruptible power supply (UPS) has been provided in the RTU Cabinet to provide backup power to the PLC, radio and instrumentation during a power outage. A dry contact in the UPS shall close to send a low UPS battery alarm signal to the PLC for display on the operator interface.

3.10 24VDC POWER SUPPLY ALARM

An 24VDC Power Supply has been provided in the RTU Cabinet to provide power to the PLC, OIT, Radio, Ethernet Switch and Soft Starter. A dry contact in the Power Supply shall close to send a Power Supply Alarm to the PLC for display on the operator interface.

****END OF SECTION****