SECTION 16100

ELECTRICAL

1. SCOPE

   A. General: Provide a complete electrical system as described herein and as shown on the drawings.

   B. Items Included: Items under Division 16 shall include but not be limited to:

      1. Power and lighting distribution complete; beginning with secondary service and extending through all branch circuits.

      2. Panelboards, breakers, and switches.

      3. Dry type transformers.

      4. Emergency generator and transfer switch.

      5. Power and control wiring for all electrically operated equipment.

2. CODES, ORDINANCES AND PERMITS

   A. General: Where requirements of these specifications exceed specified codes and ordinances conform to these specifications. Materials and equipment included in Underwriters' Label Service shall bear that label. Electrical equipment shall be UL approved as installed, unless noted otherwise herein.

   B. Permits: See General Conditions.

   C. Codes: The work covered under this section of specifications shall conform to the current edition of the following Codes and Standards as applicable.

      1. All applicable state and local codes and amendments

      2. American National Standards Institute - ANSI

      3. Institute of Electrical and Electronic Engineers - IEEE C2, National Electrical Safety Code

      4. International Code Council – ICC IBC International Building Code

      5. International Code Council – ICC IFC International Fire Code

      6. Insulated Cable Engineer's Association – ICEA

      7. National Electrical Manufacturer's Association - NEMA

      8. National Fire Protection Association - NFPA 70 National Electrical Code

      9. National Fire Protection Association - NFPA 79 Electrical Standard for Industry Machinery

      10. National Fire Protection Association - NFPA 110 Standard for Emergency and Standby Power Systems

      11. Underwriters Laboratories, Inc. Publications

3. COMPLETION OF WORK

A. Testing: At the completion of work, a test shall be made, and the entire system shall be shown to be in perfect working condition. The following shall be made available to personnel conducting the test:

1. Electrician with hand tools.
2. Accurate voltmeter.
3. Clamp-on ammeter.
4. Test lamp.
5. Phase rotation indicator.
6. Complete electrical specifications and drawings with addenda and revisions.

B. Submittal: Upon completion of work, submit for approval three bound copies of the Certificate of Final Inspection from local authorities.

C. Instructions: After completion and at a time convenient to the Owner, qualified mechanics shall thoroughly familiarize the Owner's personnel with the operation and the maintenance of the items listed under "Submittal".

D. Guarantee: All equipment and materials furnished and all work performed under this section of specifications shall be guaranteed to be free of defective materials and workmanship for a period of one year (unless a longer period is specified elsewhere herein) after final acceptance of the work by the Owner. Upon notice from the Owner of failure of any part of the guaranteed equipment or failure of systems to operate properly during the guarantee period, the affected part or parts shall be promptly replaced with new parts by the Contractor at no additional cost to the Owner. All labor required to perform guarantee shall be included as part of the complete guarantee warranty.

E. Warranties: Provide manufacturer's equipment warranties prior to final inspection.

F. Record Drawings: Furnish to the Engineer one set of as-built drawings with all changes to the project neatly drafted. Cost of the drawings and drafting shall be included under this Division.

4. SPACE CONDITIONS

A. All apparatus shall fit into the available spaces in the building and must be introduced into the building so as not to cause damage to the structure. All equipment requiring service shall be accessible.

5. DRAWINGS

A. Drawings are diagrammatic and show generally the location of the wiring, raceways, switches, and accessories and are not to be scaled. All dimensions shall be verified at the building site. Prefabrication of work from drawings shall be at Contractor's risk.

6. WORKMANSHIP AND MATERIALS

A. Workmanship: All work necessary to complete the project shall be executed in a thorough, neat, and workmanlike manner.

B. Materials: All materials shall be new, and equipment included in Underwriters Label Service shall bear that label.

C. Substitutions:

1. Basis of Design: Model numbers indicated herein or shown on the drawings are the Basis of Design. The Contractor may substitute equal and approved equipment provided said equipment meets all requirements of the plans and specifications and will fit in the available spaces as shown. The approval or disapproval of any submitted item will be considered only if submitted before beginning work. Each request shall include a description of the proposed substitute, the name of material or equipment for which it is to be substituted, drawings, cuts, performance and test data for an evaluation and a statement from the equipment manufacturer's representative that the items to be substituted meet or exceed the specifications of the item substituted for.

2. Costs: If the contractor chooses to provide equipment which meets all the aforementioned requirements but has different characteristics which cause any additional costs, he shall bear all costs associated with that substitution. All changes shall be coordinated with the Owner and Engineer.

7. SHOP DRAWINGS AND CUTS

A. Contractor's Approval: Each copy of shop drawings and cuts shall be signed and dated by Contractor as evidence of checking to ensure compliance with plans and specifications. Unsigned drawings will be returned.

B. Submittals: Shall be assembled, bound in a 3-ring binder with an index sheet showing general and subcontractor's name, address, phone number, and contact person and shall be submitted at one time unless unavailable drawings would delay project. Submittal shall include but not be limited to:

1. Panelboards
2. Loadcenters
3. Transformers
4. Circuit Breakers
5. Disconnect Switches
6. Wiring Devices and Plates
7. Conduit and Wire
8. Emergency Generator
9. Transfer Switch
10. Surge Suppression

8. APPARATUS UNDER OTHER SECTIONS

A. General: No roughing shall be done until roughing drawings are furnished.

B. Other Equipment (Existing Pump Station and Water Treatment Plant Equipment): Connect for operation and provide any appurtenances required for operation. Refer to appropriate sections of these specifications and shop drawings for more details.

9. CONDUIT

A. General: Conduit shall be galvanized rigid conduit or Schedule 40 PVC. Only rigid galvanized conduit shall be installed above ground and in or under concrete slab on grade. Conduit underground shall be PVC. Provide rigid galvanized elbow and vertical when transitioning from PVC to rigid.

B. Connectors and Couplings: Same material and finish as raceway. Rigid shall be threaded. PVC shall be glue fit type.

C. Threads: Cut clean and remove rough edges. Running threads shall not be used.

D. Pullboxes: Specified in NEC Article 370.

E. Insulating Bushings: On all conduits entering raceways, pullboxes, cabinets, stubs, panelboards, switchboard, and motor control centers.

F. Connections to Motors: Where over 18" from walls or column, a vertical conduit, minimum size 3/4" attached to ceiling and floor with wiring into and from this conduit with flexible conduit and condulets.

G. Steel Conduits in Contact with Ground: Coat complete with two coats of asphaltic paint or use conduit with 20 mil-bonded coat of PVC. All joints shall be recoated after installation.

H. Expansion Fittings: Appleton, Crouse-Hinds or O.Z. at all expansion joints.

I. Capping: Cap conduits exposed during construction to prevent entrance of moisture or foreign matter, use T&B Push-Pennies.

J. Manufacturers: Allied, LTV, Triangle, or Wheatland.

K. Conduit Routing:

1. Concealed: Where possible.

2. Exposed Routings: Run parallel or at right angles to the building lines.

3. Supports: Individual runs shall be anchored in place within 3' of changes in direction and at intervals not over 8' by means of straps or clamps specifically designed for the purpose. Wire, hanger iron, nails, and other means shall not be used. Do not strap to the piping. Multiple runs shall be supported by assemblies or trapeze type hangers to provide a rigid installation.

L. All raceways shall have an insulated copper system ground conductor.

M. Raceways which do not have conductors furnished under this Division of the specifications shall be left with an approved pullcord in raceway.

N. Conduit Installed Below Grade:

1. Bury conduit minimum 24" below finished grade beneath parking areas and drives. Bury conduit minimum 12" elsewhere.

2. Install 6" wide detectable Extra Strength Terratape within 6" of finished grade above all conduits and/or duct banks installed below grade.

10. FLEXIBLE METAL CONDUIT

A. General: Conduit shall be steel. Short lengths for connection to rotating or vibrating machinery or equipment, 6' lengths maximum for connection to lighting troffers. B-X cable is not acceptable. Flexible connections to motors shall not be less than four diameters nor more than 24" in length and shall be liquid-tight neoprene-coated for motor connections and where subjected to moisture. Provide separate grounding conductor in flexible conduits.

B. Connectors: Steel, zinc, or cadmium plated. Fittings that anchor the conduit by means of setscrews are not acceptable.

11. CONDUCTORS (50 to 600 VOLTS)

A. General: Minimum size AWG 12 copper with minimum conductance of 98% unless noted otherwise, stranded, installed in a continuous conduit system.

B. Taps and Joints: Mechanically and electrically sound. Use 3M Skotch-loks or Ideal Wing Nut for #10 and smaller. Burndy Hydent or T&B Color-Keyed on #8 and larger.

C. Tape: All joints shall be covered with gum tape and taped over with friction tape. Vinyl plastic tape may be used in lieu of gum and friction tape.

D. Terminal Lugs: Use for connecting conductors larger than #10 and for all multiple connections to terminals. Burndy Hydent to T&B Color-Keyed.

E. Lacing: All wiring in cabinets, panels, pullboxes, junction boxes are to be neatly laced and held with T&B Ty-Raps.

F. Lubricants: Electro Y-ER-EAS, Ideal Wire-Lube or Minerallac 100.

G. Color Code: Use 3/4" tape bands corresponding to color code on all wire not available with factory applied color-coding. Color code shall be as follows:

Phase	240/120	480Y/277
A	Black	Brown
B	Red	Orange
C	Blue	Yellow
N	White	Gray
G	Green	Green

The color-coding shall be permanently posted at each panelboard in accordance with NEC 210-4(d).

H. Wire Pulling: Not until conduit system is complete.

I. Conductor Insulation, Unless Noted Otherwise:

1. No. 8 and Smaller: Type "THWN-THHN"

2. No. 6 and Larger: Type "XHHW", "THW"

J. Manufacturers: Carol, Collyer, Essex, Guardian, Manhattan, Okonite, Pirelli, Rome, Royal, or Triangle.

12. OUTLET BOXES

A. General: Provide metal outlet boxes for lighting fixtures, wall switches, wall receptacles, etc., of such form and dimensions as to be adapted to their specific usage, location and size and number of conduits connecting thereto.

B. Exposed: Boxes shall be corrosion resistant cast iron.

C. Pullboxes: Shall be constructed of code gauge welded and galvanized steel. Such boxes shall be sized in accordance with NEC requirements and shall be furnished without knockouts; holes for raceways shall be drilled on the job.

D. Manufacturers:

1. Exposed: Crouse-Hinds Condulets, Appleton or Pyle.

E. Location:

1. The approximate locations of outlets are shown on the drawings. The exact locations shall be determined at the building. The right is reserved to change without additional cost the location of any outlet a maximum of 10' before it is permanently installed.

13. NAMEPLATES

A. General: Provide for all panels, circuit breakers, and safety switches. Mount on exterior of door on all surface panels or on cover plate for circuit breakers.

B. Type: White core black Bakelite for 240/120 volts and white core orange Bakelite for 480Y/277 volts, adhered with epoxy glue.

14. FUSES

A. General: Provide in all fused devices, switches, etc. This shall include equipment of other trades. Fuse sizes on drawings are based on design equipment. Contractor shall verify equipment nameplate data and size fuses accordingly.

B. 600 Amps or Less - Class RK-1 Bussmann LPN-RK-SP (250V) or LPS-RK-5P (600V) unless noted otherwise.

C. Manufacturers: Bussman as specified or by Reliance, General Electric or Ferraz Shawmut.

D. Spare Fuses: Prior to Final Inspection, provide minimum three (3) spare fuses for each type of fuse used on project.

15. PANELBOARDS

A. General: Provide automatic circuit breaker type panelboards, factory assembled with thermal magnetic molded case circuit breakers of trip ratings as shown on drawings.

B. Boxes: NEMA 4X stainless steel, and shall have code size side and end gutters, 4" minimum, 20" width x 5-3/4" depth minimum. Provide without knockouts.

C. Fronts: Surface type, constructed of stainless steel. Trim shall be completed with adjustable trim clamps and directory of glass or clear plastic. Directory to be typewritten

and shall indicate room number of service as well as use, such as: "Lights - CR 101". Trim on all flush mounted 29" wide panels shall have trim clamps and hinges completely concealed when door is closed.

D. Bus Assembly Arrangement: Distribution phase sequence type vertically numbered so that no two consecutively numbered single poles and/or spaces shall be connected to the same phase for all branch circuit breakers. All current carrying parts shall be plated. See schedules for special arrangements (i.e., split bus, R/C switches).

E. Circuit Breakers: Thermal and magnetic molded case, quick-make, quick-break, toggle operated, bolted bus bars, internal common trip, with all load side connections of the same breaker in the same gutter for multi-pole breakers. All breakers shall have interrupting capacity (UL and NEMA) as scheduled on the plans or not less than 22,000 amperes symmetrical if not noted otherwise. Series rated circuit breakers used to obtain higher than normal interruption capacities shall not be used.

F. Type: Square D as scheduled, General Electric, or Cutler Hammer.

G. Location: Contractor shall coordinate with all other trades to insure adequate mounting space and clearance before beginning work. Contractor shall provide scaled drawings showing panels and other electrical equipment coordinated with mechanical equipment and ductwork using dimensions of equipment to be furnished for the project before roughing any electrical.

16. SAFETY SWITCH, HEAVY DUTY (including double throw switches)

A. General: Provide heavy-duty safety switches having the electrical characteristics, ratings and modifications shown on the drawings. All switches shall have NEMA 4X stainless steel enclosures; handle whose position is easily recognizable that is integral with the switch base and is padlockable in the "OFF" position; visible blades, reinforced fuse clips; non-teasible, positive, quick-make, quick-break mechanisms and switch assembly plus operating handle as an integral part of the enclosure base. All switches shall be UL listed, HP rated, shall have defeatable door interlocks that prevent the door from opening when the operating handle is in the "ON" position and shall have line terminal shields.

B. Manufacturer: General Electric, Square D, or Cutler Hammer.

C. Nameplates: Label each device as specified under "Nameplates".

17. ENCLOSED CIRCUIT BREAKERS

A. General: Provide enclosed circuit breakers having the electrical characteristics, ratings and modifications shown on the drawings. All enclosed circuit breakers shall have NEMA 4X stainless steel enclosures; handles that are padlockable in the "OFF" position and remain in positive contact with the breaker handle at all times; nonteasible, positive, quick-make, quick-break mechanisms. Circuit breakers shall be molded case and have minimum interrupting capacity (UL and NEMA) as shown on the plans or not less than 22,000 amperes symmetrical. Series rating of circuit breakers is not permitted.

B. Manufacturer: General Electric, Square D, or Cutler Hammer.

C. Nameplates: Label each device as specified under "Nameplates".

18. GROUNDING

A. General: Provide grounding for the following items as required by National Electrical Code and as indicated and specified herein:

1. Conduit and other conductor enclosure.

2. Neutral or grounded conductor of interior wiring system.

3. All panelboards, safety switches, non-current carrying parts of fixed equipment, such as motor and starters.

4. Provide a separate grounding conductor in all conduits.

5. Provide a grounding conductor for ground pole on each receptacle and toggle switch.

6. The electrical system shall be supplemented with equipment grounding systems. Where possible, ground electrical system to building steel and metal water service.

a. Ground rods shall be 3/4" copper weld rods 10'-0" in length. Not more than four 10'-0" rods shall be required and these shall be installed not less than ten feet apart.

b. Top of ground rods shall be twelve inches below finished grade. Connections to ground rods shall be made by chemical weld process.

c. Resistance to ground shall not exceed twenty-five ohms.

d. Upon completion of the ground rod installation, the Contractor shall test the installation. Ground resistance readings shall not be taken within forty-eight hours of rainfall.

e. Each ground rod installation shall be tested after all connection to ground rods are made but before grounding conductor connection is made to the building cold water system. Ground rod installations shall be tested by "fall of potential" measuring method using ground resistance test meter and two auxiliary electrodes driven into the earth, interconnected through the meter with the ground rod installation being tested. Placement of auxiliary electrodes shall be in accordance with operating instructions of test meter, but in no case shall auxiliary current electrodes be placed within seventy feet of the grounding system being tested. Test data shall indicate placement of auxiliary electrodes with respect to system being tested; date readings were taken and lowest resistance recorded.

f. Three (3)-typewritten copies of the test shall be submitted to the Engineer for approval.

g. If the resistance to ground is above twenty-five ohms after installation of four ground rods, provide test information to engineer.

19. WIRING DEVICES

A. General: Provide devices as specified herein and as shown on the drawings. Receptacles not specified herein nor scheduled on drawings but shown on the drawings shall be of similar construction and NEMA configuration.

B. Devices:

1.	Switches:	Arrow Hart
	SPST	1991-I
2.	Convenience Outlets:	Arrow Hart
	Duplex	5362-I
	Ground Fault	GF5342-I

Receptacles on dedicated circuit shall be 20 AMP rated

C. Alternate Manufacturers: Leviton, Hubbell, Pass & Seymour.

20. DEVICE PLATES

A. General: Provide suitable plate for all outlets.

B. Weatherproof covers shall be Tay Mac 20310.

21. SURGE SUPPRESSORS

A. General: Provide transient voltage surge suppressors (TVSS) for the protection of all AC electrical circuits from the effects of lightning induced currents, substation switching transients and internally generated transients resulting from inductive and/or capacitive load switching on the main service equipment and on panels as indicated.

B. Primary Service Suppressors (Main Service Equipment):

1. Suppressors shall be listed in accordance with UL 1449, UL 1283 and CSA listed.

2. For 3-phase, 4-wire configurations, suppressors shall provide suppression elements between each phase conductor and the system neutral, including neutral and ground.

3. Surge Suppressors shall be provided with integral disconnect and overcurrent protection.

4. Suppressor shall provide certified test data confirming a fail short failure mode.

5. Visible indication of proper suppressor connection and operation shall be provided.

6. Suppressors shall be close nippled to the equipment being protected. The mounting position of the suppressor shall permit a straight and short lead length connection between the suppressor and the point of connection to the equipment.

7. Connections utilizing conduit between suppressors and equipment will not be accepted.

8. Suppressors shall meet or exceed the following criteria:

a. Maximum surge current rating: 100,000 amperes

b. Life Cycle Testing: 20 KV, 10KA, IEEE C62-41. Category C3 surge current with less than 5% degradation of clamping voltage. 1250 occurrences (minimum).

c. Suppressors shall have turn-on and turn-off times of less than .5 nanosecond.

d. Suppressors shall be constructed using multiple surge current diversion modules utilizing metal oxide varistors (MOV).

9. Suppressor shall be installed on the load side of the first disconnecting point of the service.

10. Conductors between suppressor and point of attachment shall be kept as short and straight as possible.

11. Provide a five-year warranty to include one free replacement of surge suppressor if destroyed by lightning during warranty period.

12. Suppressors shall be Leibert S277/480 Y11 or by Current Technology, LEA Dynatech, APT or Tycor.

END OF SECTION