SECTION 16400

SERVICE AND DISTRIBUTION

PART 1 - GENERAL

1.1 DESCRIPTION

B. Provide a complete Electrical Service and Distribution system in each building as indicated on the "Single- Line Diagrams" and as specified herein.

1.2 QUALITY ASSURANCE

A. The equipment specified herein is based upon the first manufacturer named after the phrase "Acceptable Manufacturer's". Equipment types, device ratings, dimensions, etc. correspond to the nomenclature dictated by that manufacturer. Equipment of other acceptable manufacturer's shall be equivalent in every way to that of the equipment specified.

B. All equipment shall be tested at the factory. Unless specified elsewhere, standard factory inspection and operational tests will be acceptable.

1.3 SUBMITTALS TO THE ENGINEER

A. Submit Shop Drawings for all service and distribution equipment specified herein including the following information:
   1. Manufacturer and equipment type.
   2. Standard catalog information sheet.
   3. Detailed Shop Drawings indicating plan, elevation, end, and isometric views.
   4. Single-line diagram.
   5. Schematic / wiring diagrams
   6. Complete bill of materials.
   7. Additional information necessary to verify equipment to be supplied has features specified.
   8. The above shall be submitted in a single complete brochure which shall be in the form of a soft cover binder with index tabs.

B. Submit documentation of all grounding tests.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Dry Type Distribution Transformers (1500 kVA and Below)
   1. General:
      a. Furnish and install, single phase and three phase general purpose individually mounted dry-type transformers of the two-winding type, self-cooled, with ratings and voltages as indicated on the drawings. Transformers shall be manufactured by Cutler-Hammer or equivalent by Square D, General Electric, Hevi-Duty, or Acme.

b. Transformers shall be designed, manufactured, and tested in accordance with all the latest applicable ANSI, NEMA, and IEEE standards. All 600 volt class transformers shall be UL listed and bear the UL label.
c. Transformers shall be designed for continuous operation at rated kVA, for 24 hours a day, 365 days a year operation, with normal life expectancy as defined in ANSI C57.96.

2. Insulation Systems:
   a. Transformers shall be insulated as follows:

      2 kVA and below: Class B insulation for 150 degrees C total temperature, based on 80 degree C rise.

      3 through 30 kVA: Class F insulation for 185 degrees C total temperature, based on 115 degree C rise.

      30 kVA and above: Class H insulation for 220 degrees C total temperature, based on 150 degree C rise.
   b. Required performance shall be obtained without exceeding the above indicated temperature rise in a 40 degree C maximum ambient, with a 30 degree C average ambient over 24 hours.
   c. All insulation material shall be flame-retardant and shall not support combustion as defined in ASTM Standard Test Method D635.
3. Core and Coil Assemblies:
   a. Transformer core shall be constructed with high grade, non-aging, grain-oriented silicon steel with high magnetic permeability, and low hysteresis and eddy current losses. Maximum magnetic flux densities shall be substantially below the saturation point. The transformer core volume shall allow efficient transformer operation at 10% above the highest tap voltage. The core laminations shall be tightly clamped and compressed. Coils shall be wound of electrical grade aluminum with continuous wound construction.
   b. On units rated below 30 kVA, the core and coil assembly shall be completely encapsulated in a proportioned mixture of resin and aggregate to provide a moisture-proof, shock resistant seal.
   c. On units rated 30 kVA and above, the core and coil assembly shall be impregnated with a non-hydroscopic, thermo-setting varnish and cured to reduce hot spots and seal out moisture. The assembly shall be installed on vibration-absorbing pads and securely bolted to the base to minimize sound transmission.
4. Enclosures:
   a. The enclosure shall be made of heavy gauge steel and shall be degreased, cleaned, primed, and finished with ANSI 61 color weather-resistant enamel. All transformers shall be equipped with a wiring compartment suitable for conduit entry and large enough to allow convenient wiring.

The maximum temperature of the enclosure shall not exceed 90 degrees C. The core of the transformer shall be visibly grounded to the enclosure.

b. On units rated below 30 kVA, the enclosure construction shall be totally enclosed, non-ventilated, NEMA 3R, with lifting eyes.

c. On units rated 30 kVA and above, the enclosure construction shall be ventilated, NEMA 2, drip-proof, with lifting holes. All ventilation openings shall be protected against falling dirt. On outdoor units, provide suitable weathershields over ventilation openings.

5. Transformer sound levels shall not exceed the following ANSI and NEMA levels for self cooled ratings:

Up	to	9 kVA	40 db
10	to	50 kVA	45 db
51	to	150 kVA	50 db
151	to	300 kVA	55 db
301	to	500 kVA	60 db
501	to	700 kVA	62 db
701	to	1000 kVA	64 db
1001	to	1500 kVA	65 db

6. The following tests shall be made on all transformers:
   a. Ratio tests on the rated voltage connection and on all tap connections.
   b. Polarity and phase-relation tests on the rated voltage connection.
   c. Applied potential tests
   d. Induced potential test

B. Panelboards - Lighting and Distribution (480 volt, 480Y/277 volt, and 208Y/120 volt)

1. General:
   a. The contractor shall furnish and install at locations as shown on the drawings approved panelboards of a type indicated and specified herein.
   b. Panels identified for use as service entrance equipment shall be so labeled.
   c. Panelboards shall comply with the applicable sections of UL, NEC and NEMA and shall be as manufactured by Cutler-Hammer or equivalent by General Electric Co. or Square D Co.
2. Interiors:
   a. Interior shall be completely factory assembled with bolt-on devices. They shall be designed such that switching and protective devices can be replaced without disturbing adjacent units and without removing the main bus connectors.
   b. Unless otherwise noted, full size insulated neutral bars shall be included. Bus bar taps for panels with single pole branches shall be arranged for sequence phasing of the branch circuit devices. Neutral bussing shall have a suitable lug for each outgoing feeder requiring a neutral connection.

c. Main bus bars shall be copper sized in accordance with UL standards to limit temperature rise on any current carrying part to a maximum of 50 degrees C above an ambient of 40 degrees C maximum.
d. A ground bus shall be included in all panels.

3. Boxes:
   a. Boxes shall be at least 20 inches wide made from galvanized steel. Provide minimum gutter space in accordance with the National Electrical Code. Where feeder cables supplying the mains of a panel are carried through its box to supply other electrical equipment, the box shall be sized to include the additional required wiring space. At least four interior mounting studs with adjustable nuts shall be provided.
   b. Boxes shall be provided with removable blank ends.
4. Trims:
   a. Trims for lighting and appliance panelboards shall be supplied with a hinged door over all circuit breaker handles. Doors in panelboard trims shall not uncover any live parts. Doors shall have a semi-flush cylinder lock and catch assembly. Doors over 48 inches in height shall have auxiliary fasteners.
   b. Distribution panelboard trims shall cover all live parts. Switching device handles shall be accessible.
   c. Surfaces of the trim assembly shall be properly cleaned, primed and a finish coat of gray ANSI 61 paint applied.
   d. Surface trims shall be same height and width as box. Flush trims shall overlap the box by 3/4 of an inch on all sides.
   e. A directory card with clear plastic cover shall be supplied mounted on the inside of each door.
   f. Provide an engraved nameplate for each panel section.
5. Panelboard Ratings:
   a. Panelboards rated 240 VAC or less shall have short circuit ratings as shown on the drawings or as herein scheduled, but not less than 10,000 amperes rms symmetrical.
   b. Panelboards rated 480 VAC shall have short circuit ratings as shown on the drawings or as herein scheduled, but not less than 14,000 amperes rms symmetrical.
   c. Breakers shall be a minimum of 100 ampere frame. Breakers 15 through 100 amperes trip size shall take up the same pole spacing.
   d. Panelboards shall be labeled with a UL short circuit rating. When series ratings are applied with integral or remote upstream devices, a label shall be provided. Series ratings shall cover all trip ratings of installed frames. It shall state the conditions of the UL series ratings including:
      1) Size and type of upstream device
      2) Branch devices that can be used
      3) UL series short circuit rating

C. Variable Frequency Drives (VFD's):

1. All variable frequency drives, provided under this Division, must be supplied by the same manufacturer and meet all specified requirements. The drives shall be manufactured in an ISO-9001 certified manufacturing facility. Contractor shall coordinate variable frequency drive manufacturer selection with all equipment manufacturers, and shall be solely responsible for ensuring that the individual variable frequency drives furnished are completely compatible with all requirements and intended functions of the driven equipment. Acceptable variable frequency drive manufacturer is Toshiba (G7 Series), no substitutions.
2. The drive shall be capable of varying the speed of a standard NEMA Design B induction motor from a virtual standstill to the standard base speed of the motor. The unit shall transform input power into a variable voltage, adjustable frequency three phase output of suitable capacity and waveform. The drive shall be capable of operation with the motor disconnected without damage to the drive components.
3. Input voltage shall be as indicated on the Drawings and/or as specified in the equipment specification sections. Frequency shall be 60 Hz.
4. Output shall be three (3) phase voltage as indicated on the Drawings and/or as specified in the equipment specification sections.
5. The drive shall be a PWM (Pulse Width Modulated) inverter using latest generation IGBT transistors. The drive shall incorporate phase-to-phase and phase-to-ground MOV protection. The drive input shall employ diode or fully gated bridge rectification for conversion of AC to DC.
6. The drive manufacturer shall have not less than fifteen years of experience in the manufacture of drives in the United States.
7. The drives shall be rated for constant torque or variable torque applications, depending on the individual driven load requirements.
8. Power Line Considerations:
   a. The drive shall be designed to operate in accordance with all performance requirements of the contract documents from a power source which contains a maximum of 5% total voltage harmonic distortion, and shall meet current distortion as defined by IEEE-519-1992.
   b. Each VFD or multiple sets of VFD's shall be designed and installed such that the total voltage harmonic distortion reflected back to the power source is a maximum of 5%. The total voltage and current harmonic distortion shall be as defined by IEEE-519-1992.
   c. Line reactors with an impedance of three percent (3%) shall be provided for all VFD's. Line reactors shall be provided by VFD supplier and shall be rated for, and compatible with, each VFD. They shall function as a complete system. The line reactors shall be mounted inside the VFD Control Panel. Line reactors shall be TCI, or equivalent. Data on these items shall be included with VFD shop drawings.
9. Ambient Conditions:

a. Environment - Indoors, NEMA 1 enclosure with fans and filters when required for drive cooling, unless located in space with different NEMA rating.
b. Ambient Temperature - minus 10 degrees C to 40 degrees C
c. Altitude - Less than 3,300 feet
d. Relative humidity - 95% maximum non-condensing
e. Vibration - less than .5G

10. Control System:
    a. Input power: A. Main Power circuit: 480V/3 Phase/60Hz.
       B. Control circuit: 120 volts; no external source for 120 volt control power shall be required.
    b. Tolerance: Input Voltage $\pm$ 10%. Frequency $\pm$ 5 Hz.
    c. Control method: Sinusoidal PWM control with Volts/Hz, Sensorless Vector, or Flux Vector where required.
    d. Output Voltage: 3 Phase, 0 - 460 Volts.
    e. Output Frequency Range: 0 Hz to 400 Hz
    f. Volts/Hz characteristics:
        1) Either constant V/Hz or variable V/Hz (user selectable)
        2) Minimum frequency adjustable from 0 Hz to 120 Hz
        3) Maximum frequency adjustable from 10 Hz to 400 Hz
        4) Voltage boost adjustable from 0% to 30%
    g. Overload current: Variable torque (Normal Duty) applications: 110% for up to 60 seconds and 150% for up to 3 seconds. Constant torque (Heavy Duty) applications: 150% for up to 60 seconds and 200% for up to 3 seconds.
    h. Analog Inputs: (2) 4-20 mA or 0-10 volts
    i. Analog Outputs: (2) 4-20 mA (speed and motor running amps)
    j. Input Terminals: Minimum of six (6) programmable
    k. Output Contacts: three (3) programmable Form C contacts, rated 250V, 2 amps inductive, shall be provided by interposing relays.
    l. Frequency jump - 3-point settings: Setting jump frequency (0 to Max frequency), and width (0 to max frequency).
    m. PWM carrier frequency: Adjustable from 2 kHz to 10 kHz.
11. The drive shall provide a minimum displacement power factor of 0.95 throughout the speed range.
12. The efficiency of the drive at full speed shall be a minimum of 97.5 percent.
13. The drive shall be provided with an MCP-type circuit breaker with through-door padlockable disconnect handle, to serve as a disconnecting means, and coordinated with the drive protective features for the motor to form a complete combination type starter/controller. Provide with current limiting fuses on the input side of the drive, sized and rated as required by UL and the drive manufacturer, so that the drive is rated for the available fault current. The short circuit current rating of the drive assembly shall be at least 65,000 amps RMS symmetrical, unless otherwise specified or noted on Drawings.

14. The drive shall be provided with an EMI/RFI filter as manufactured by TCI or equivalent.
15. The drive panel shall contain relays, selector switches, push buttons, pilot lights, timers, elapsed time meters, and all other appurtenances necessary for the specific application as specified in the Equipment, Instrumentation, and Electrical specification sections, and as indicated on the Instrumentation and Electrical Drawings. Front-mounted pilot lights, switches, pushbuttons, and appurtenances shall be provided in accordance with specification Section 16900.
16. Enclosure type shall be as required for the specific application as shown on the Drawings. VFD Control Panel shall conform to the requirements of Section 16160. All components for each VFD, including inverter, input line reactor, and all other appurtenances shall be installed into a NEMA enclosure and the total assembled unit shall be UL listed and labeled for the VFD units being provided.
17. Operational Functions:
    a. Acceleration/deceleration times: 0.1 to 3600 seconds, 2 separate acceleration and deceleration times.
    b. Current Limit: Programmable current limit from 0.1 amps to 150% of drive rated amps.
    c. Forward or reverse run can be chosen.
    d. Jogging:
        1) Running - 0 to 20 Hz
        2) Braking - Deceleration, DC injection, or coasting
    e. Multi-speed run: Up to 7 preset speeds can be chosen.
    f. Flying Start: The drive shall be capable of determining the speed and direction of a spinning motor and adjust its output to "pick up" the motor at the rotating speed.
    g. Automatic Restart: In the event of power loss, the drive shall automatically restart without requiring an external reset.
    h. Fault Memory: Last eight (8) fault codes with respective times shall be stored in a fault buffer.
    i. Inertial Ride-through: Drive shall respond to brief loss of AC input power by utilizing motor regenerative voltage to continue operation during the outage. Undervoltage detection shall be adjustable.
    j. Fault Reset / Run: Drive shall provide for automatic fault reset and restarts following certain fault conditions before locking out and requiring manual reset. Time between restarts shall be adjustable from 0.5 seconds to 30 seconds.
    k. Soft Stall: Sustains a run in overload mode.
    l. Overload: Internal Class 10 overload protection, speed sensitive and adjustable from 60 - 100%.
    m. Complete adjustment of parameters gives thousands of volt/frequency patterns.

18. Protective Features:
    a. Functions included:
       Overcurrent
       Overvoltage
       Heatsink Overheat
       Load-side Short Circuit
       Load-side Ground Fault
       VFD Overload
       Overcurrent During Start-up
       EEPROM Error
       Communications Error
       Auto-Tuning Error
       Emergency Stop
       Undervoltage
       Open Output Phase
       Motor Overload
    b. Drive shall have an external fault trip input terminal.
    c. Drive shall reset when a designated contact is closed on the terminal strip.
19. Metering Functions:
    The following parameters shall be accessible through the controller:
    a. Output current in Amps
    b. Output voltage in Volts
    c. Output power in kW
    d. Elapsed MWh
    e. DC Bus Voltage
    f. Output frequency
    g. Heatsink temperature
    h. Last eight (8) faults
    i. Elapsed run time
20. Controller:
    a. The controller shall be common for all horsepower ratings. The controller shall include a seven line by 21 character backlit LCD digital display, programming keypad, and operator key options. All parameters shall be adjustable from the keypad. The controller shall use expanding tree topology, and all parameters shall be displayed in an easily understandable format using plain English.
    b. The drive shall have a reset to factory default settings.
    c. The keypad shall be NEMA 1 or NEMA 12 rated; keypad rating shall match the enclosure rating.
    e. The keypad shall be able to extend up to 15 feet from the drive.
    f. The keypad shall allow for parameters to be changed while drive is running.
21. All models shall be UL listed.

22. Drive shall be capable of communication through a standard protocol which will support RS232 and RS485, as standard. The drive shall be able to communicate with at least two networks simultaneously. Preferred networks are Ethernet, ControlNet, or DeviceNet.
23. Drive shall be capable of PID control.
24. Drive shall be capable of speed feedback control through an optional control board.
25. Variable frequency drive manufacturer must have a local factory-authorized parts-stocking distributor which has factory-trained service technicians and warranty authorization, and shall have 24 hour service capabilities.
26. Variable frequency drive manufacturer shall provide all required start-up services. At a minimum, these shall include a pre-power check of grounding and all connections, drive power-up and commissioning, a written record of all voltage, current, and power measurements, drive tuning for system operation, and a complete listing of all drive parameters provided for the Owner's use.
27. Variable frequency drive manufacturer shall provide all required on-site training of Owner's personnel. At a minimum, the training shall include:
    a. Review of submittal drawings identifying components shown on drawings.
    b. Review starting / stopping and speed control options.
    c. Review operation of the controller for programming and monitoring of the variable frequency drive.
    d. Review maintenance requirements of the variable frequency drive.
    e. Review safety concerns with operating the variable frequency drive.
28. Variable Frequency Drive Schedule:

Equipment Name	HP	Constant or Variable Torque	Supplier
Sodium Hypochlorite Feed Pump HYP-1	3/4	CT	Pump Supplier
Sodium Hypochlorite Feed Pump HYP-2	3/4	CT	Pump Supplier
Sodium Hypochlorite Feed Pump HYP-3	3/4	CT	Pump Supplier
Sodium Hypochlorite Feed Pump HYP-4	3/4	CT	Pump Supplier
Sodium Hypochlorite Feed Pump HYP-5	3/4	CT	Pump Supplier
Sodium Hypochlorite Feed Pump HYP-6	3/4	CT	Pump Supplier
Sodium Hypochlorite Feed Pump RAS HYP-1	3/4	CT	Pump Supplier
Sodium Hypochlorite Feed Pump RAS HYP-2	3/4	CT	Pump Supplier

PART 3 - EXECUTION

3.1 INSTALLATION

A. Grounding:

1. Provide equipment grounding systems as dictated by Article 250 of the National Electrical Code and as indicated in Section 16450 and on the Contract Documents. Service entrance ground conductors shall be copper with green thermoplastic insulation installed in rigid galvanized steel conduit.
2. Ground all exposed non-current carrying metallic parts of the electrical system and ground all raceway systems.
3. Ground all transformer enclosures and secondary neutral connections.
4. Ground all motor frames using copper bonding conductor between raceway system and motor frame.

B. All floor mounted electrical equipment shall be mounted on 4" high concrete pads which shall extend 2" on exposed sides. Securely bolt each unit to its pad for proper horizontal and vertical alignment. Use shims where necessary.

C. Inspect all bus bolts in panelboards prior to energizing to check for looseness developed during shipment or handling.

D. Install dry-type transformers with adequate clearances for proper ventilation. Bolt floor mounted transformer to concrete pad utilizing neoprene vibration damping pads.

E. Panelboards:
1. All panelboards shall be installed so that the top circuit breaker handle is not higher than 6'-6" above finished floor.
2. Panels to be installed in unfinished rooms shall be mounted to framing channels. Panels shall not be hung directly off walls.
3. Loads shall be balanced on all phases and branch circuiting rearranged, if required, for balancing.
4. Provide and install panelboards in the number, sizes and construction as stated in the panelboard schedules.

3.2 TESTS

A. Grounding:
1. Grounds and grounding systems shall have a resistance to solid earth ground not exceeding following values:

	Ohms
For grounding secondary service neutral	25
For grounding non-current carrying metal parts associated with secondary distribution system	25

2. Provide grounding tests to verify the above values. Where these values are not met, add additional ground rods in order to meet these values.

END OF SECTION