SECTION 16425

SWITCHBOARDS

PART 1 - GENERAL

1.01 SCOPE

A. Work Included: All labor, materials, appliances, tools, equipment necessary for and incidental to performing all operations in connection with furnishing, delivery and installation of the work of this Section, complete, as shown on the drawings and/or specified herein. Work includes, but is not necessarily limited to the following:
   1. Examine all other specification sections and drawings for related work required to be included as work under Division Sixteen.
   2. General provisions and requirements for electrical work.

1.02 SUBMITTALS

A. Provide schematic "ladder type" logic control wiring diagrams and "point-to-point control wiring diagrams showing control and protective systems interlocks.

B. Provide nameplate engraving schedule.

C. Submit full-scale time/current transparencies on log/log paper for all fuses, circuit breakers, ground fault system devices, and relays.

D. SHORT CIRCUIT AND ARC-FAULT

   1. Perform coordination study and submit engineered settings for each fuse and adjustable circuit breaker device, showing the correct time and current settings to provide the coordination within the limits of the specified equipment, per the latest applicable standards of IEEE and ANSI. Provide Electric ARC-FLASH calculations as part of the coordination study recommendations. The information shall be submitted in both tabular form and on time current log-log graph paper, with a engineering narrative, (6) six copies.
   2. The goal is to minimize an unexpected but necessary electrical system outage and personnel exposure to the smallest extent possible within the fault occurrence location, using the specified contract equipment, including but not limited to:
      a. IEEE-242, Recommended Practices for Protection and Coordination of Industrial and Commercial Distribution.
      b. IEEE-1584, Guide to Performing ARC-FLASH Hazard Study.
      c. CEC/NEC

E. Factory Tests: Switchgear tests - ANSI C37.20. Certified copies of design tests, production tests, and conformance tests of the switchgear shall be submitted and review comments shall be received before delivery of equipment to the project site. In lieu of the above tests, a report of these tests previously performed on identical units of each rating will be acceptable.

1.03 APPLICABLE STANDARDS

A. The switchgear equipment shall be designed, tested and assembled to comply with ANSI, IEEE, and NEMA and U.L.

B. Equipment components/devices, switchboards, and/or switchgear shall be manufactured by: General Electric, Cutler-Hammer, Square–D, Eaton or Siemens.

PART 2 - PRODUCTS

2.01 BUSSING

A. Horizontal and vertical busses shall be full lengths in each equipment section. Buses shall have a minimum withstand rating equal to available fault current indicated on drawings, but in no case shall the rating be less than 50,000 amperes, symmetrical.

B. Provide interconnected full capacity neutral bus in each section with the same ratings and construction as the phase busses.

C. Provide interconnected ground bus in each section.

D. Provide space and all hardware and mounting attachments for future devices as indicated on the drawings.

E. Main horizontal bussing shall be full capacity in all switchboard sections.

F. Vertical buss may be tapered, to not less than one third the ampacity rating of the main horizontal buss; but in no case shall the vertical buss be of less capacity than the sum of the frame size ampacities of overcurrent devices mounted in the respective sections including any indicated spares and spaces.

G. The switchboard bussing shall be of sufficient cross-sectional area to meet UL Standard 891 on temperature rise Bus shall be copper with silver plated bus joints aluminum bussing is not allowed. The through bus shall have provisions for the addition of future sections. The through bus supports, connections and joints are to be bolted with grade 5 hex head bolts and Belleville washers to minimize maintenance requirements.

2.02 CIRCUIT BREAKERS

A. General
   1. Circuit protective devices as indicated on the drawings. All devices shall have an interrupting capacity not less than the maximum available fault current at the circuit breaker as indicated on the drawings, but in no case shall the interrupting capacity be less than 30,000 ampere symmetrical interrupting for 480/277 volt devices and 42,000 ampere symmetrical for 240 volt or 208/120 volt devices.
   2. Provide padlock-off devices on each device. Breakers shall provide time overcurrent and instantaneous circuit protection.
   3. Circuit breakers shall employ a stored energy, quick make-quick break, and trip free operating system on each phase, with common trip. Breakers shall comply with U.L. 489 and NEMA AB1 latest revisions.
   4. Circuit breakers noted as "100%" on the drawings shall be tested and rated to carry the breaker full rated (100%) ampere load continuously including the assemblies the circuit breakers are installed into.
   5. Provide conductor lugs on circuit breakers to accept conductor sizes and quantities shown on drawings.
   6. Circuit breaker data monitoring and communications:
      a. The circuit protection devices shall monitor, communicate and report circuit voltage, ampere, power, and harmonic parameters for the respective feeder or main circuit. The circuit protection device monitor and communication parameters shall be the same and compatible with the specified "METERING" devices.

b. Additionally the circuit protection devices shall monitor and communicate the respective device status as follows:
   1) Open/close/trip device status
   2) Ground fault trip status (where applicable)

c. Provide circuit breaker data monitoring and communications for each of the individual feeder protection devices and main protection devices located in switchgear and switchboards, rated 225 ampere or greater trip rating.

d. The respective "METER" display selection control functions shall provide selection and display of all information monitored and communicated by individual protection devices on the respective meter alphanumeric display.

7. Electrical equipment including switchgear, switchboards, electric panels and control panels, motor control centers, combination motor starters, transformers, disconnects, etc., shall each be labeled by the manufacturer with "Electric-ARC-FLASH" warning signs. The signs shall explain a hazard to personnel may exist if the equipment is worked on while energized or operated by personnel while energized. The sign shall instruct personnel to wear the correct protective equipment/clothing (PPE) when working "Live", or operating "Live" electrical equipment and circuits.

B. Performance requirements for circuit breakers conforming to one or more of the following applications:
- 600 Ampere or larger frame size.
- Larger than 400 Ampere trip.
- Service entrance in main switchboard.
- Noted as main circuit breakers on the drawings.

1. Circuit breaker shall employ current sensors and static electronic automatic trip system. Three phase, or single-phase operation as noted on the drawings. Current carrying components shall be completely isolated from the static trip units. The trip unit shall be independent of external power sources. Circuit breaker shall be U.L. listed for reverse connection.

2. Breaker solid state trip control functions shall provide the following field adjustable features;

   a. Adjustable ampere setting to vary the continuous current carrying capacity, minimum range of 80% thru 100% of full load trip rating.

   b. Adjustable long-time delay setting to vary the time the breaker will trip under sustained overload conditions. Minimum of three settings, "minimum - intermediate - maximum".

   c. Adjustable short-time pickup to vary the level of high current the breaker can carry for short periods of time, minimum range of 2 times thru 8 times of ampere setting.

   d. Adjustable short time delay to vary the time of the short-time pickup. Minimum of three settings "minimum-intermediate-maximum".

   e. Short time "I^2t" switch to allow a current-squared multiplied by time ramp function in the short-time system. Two position setting "in-out".

   f. Adjustable instantaneous pickup to vary the breaker ampere setting for immediate (instantaneous) interruption of severe overloads (short circuits). Adjustable minimum range of 2.0 times thru 9 times of circuit breaker ampere sensor rating. (note where the coordination study requires a higher instantaneous setting, change the specified adjustable instantaneous trip to fixed instantaneous trip at 15 times the breaker ampere sensor setting).

   g. Individual fault trip indicators shall provide local indication on the breaker for overload and short circuit (and ground fault where applicable) conditions.

   h. Provide one manufacturer standard test set for solid state trip circuit breakers.

C. Performance requirements for circuit breakers conforming to one or more of the following applications:
- Smaller than 600 ampere frame size.
- 400 ampere and smaller trip.

- 225 ampere and larger frame size.
- Larger than 100 ampere trip.

1. Circuit breaker shall be molded case thermal-magnetic or solid-state trip. Thermal-magnetic circuit breakers shall be furnished with field adjustable, instantaneous magnetic trip element.
2. Solid state trip breakers shall conform to the requirements described for solid state breakers larger than 400 ampere trip except, only the following field adjustments are required;
   a. Ampere setting adjustable minimum range of 80% thru 100% of full load trip rating.
   b. Short time pickup adjustable minimum range of 2 times thru 8 times of the ampere setting.
   c. Fixed or field adjustable instantaneous trip.

D. Performance requirements for circuit breakers conforming to the following applications:
- 100 ampere frame size and smaller.
- 100 ampere and smaller trip.

1. Circuit breaker shall be molded case thermal-magnetic trip.

E. Current Limiting Circuit Breakers (CLCB)
1. Performance requirements for circuit breakers conforming to the following applications:
   - 400 ampere and smaller trip and identified as current limiting (CLCB) on the drawings.

   a. Current limiting circuit breakers shall be supplied in unit molded case construction and shall consist of a common trip, thermal-magnetic circuit breaker with an independently operating limiter section in series with each pole. The conventional breaker section shall have an overcenter, trip-free, toggle-type mechanism with quick-make, quick-break action and positive handle indication. A button shall be provided on the cover for mechanically tripping the circuit breaker. The current limiting breaker shall have permanent trip units containing individual thermal and magnetic trip elements in each pole. The thermal trip element shall be calibrated for 40 degrees C ambient temperature. The limiter section shall consist of three current limiting elements electrically coordinated with the conventional circuit breaker trip elements. The contacts of the limiter section shall be electro-magnetically and electrodynamically opened and held open until interruption is complete.
   b. Current and Energy Limitations: On high-level fault currents the limiter portion of the circuit breaker shall operate to limit the rise of fault current. Integral resistance shall be introduced into the faulted circuit to dissipate and limit let-through energy and to provide a voltage transient-free interruption at near unity power factor Let-through current and energy levels for 100, 200 and 400 ampere breakers shall be less than that permitted by Underwriters Laboratories for 100, 200 and 400 ampere, Class RK-1 fuses, respectively. On fault currents below the threshold of current limitation, the thermal-magnetic breaker section shall provide conventional overload and short circuit protection.
2. Performance requirements for circuit breakers conforming to the following applications:
   - Trip ratings over 400 ampere and 1200 ampere or less. Identified as current limiting (CLCB) on the drawings.

   a. Integrally fused circuit breaker consisting of integrated molded housing in which is combined (1) a standard molded case circuit breaker providing overload-short circuit protection within its interrupting capacity and ON-OFF switching function and (2) current limiters internally mounted on the load side of the circuit breaker of such ratings that their time current limiting characteristics will coordinate with the time current tripping characteristics of the circuit

breaker elements. The coordination shall result in the interruption by the circuit breaker alone of fault level currents up to the interrupting capacity of the circuit breaker and interruption by the current limiter in conjunction with the circuit breaker of fault level currents above the interrupting capacity of the circuit breaker.

b. A removable cover shall be provided over the current limiter section of the integrally fused circuit breaker. The current limiter housing covers shall be interlocked with the breaker tripping mechanism to insure the breaker will trip upon removal of the cover. The cover shall be interlocked with the breaker to insure the circuit breaker cannot be turned to the ON position with the cover removed. Current limiters shall have a spring loaded plunger which, when the limiter blows, is released to actuate the circuit breaker common trip bar mechanism opening all breaker poles simultaneously.

c. The limiters shall be individually interlocked with the breaker element tripping mechanism to insure the limiter cannot be inserted until the breaker is in the OFF position. The circuit breaker and limiters shall be interlocked to insure the circuit breaker cannot be closed if a limiter is either missing or has blown.

d. Fuse limiters shall be individually removable from the molded case housing.

e. The molded case circuit breaker shall be ambient temperature compensating. The circuit breaker shall be provided with thermal magnetic trip rated - amperes continuous current.

f. The integrally fused circuit breaker shall be capable of interrupting available short circuit currents up to 200,000 RMS symmetrical amperes at voltage up to 600 VAC.

g. Ratings, clearances and performance of the integrally fused circuit breaker shall be in accordance with applicable standards of NEMA, IEEE and ASA.

2.03 GROUND FAULT PROTECTIVE SYSTEM AS FOLLOWS:

A. One control power transformer rated 480/120 volts of suitable capacity for shunt tripping of the main circuit breaker and subfeed circuit breakers as indicated on the drawings. Fuse transformer on the 480-volt side.

B. Ground sensor current transformer for each indicated ground fault relay, zero sequence type with integral test winding for each circuit indicated on drawings. (The three phases and neutral conductor shall be brought through the current transformer window per manufacturer's recommendations).

C. One ground break, solid-state relay, and monitor and test panel for each device indicated on the drawings. Pick-up adjustment shall be continuous 100 through 1200 ampere; time adjustment shall be continuous from instantaneous through 60 cycles. Monitor panel shall indicate relay operation and provide means for system testing with or without interruption of service, and shall not permit system to be inadvertently left in an inactive or off state. Provide resettable trip indicators.

D. System shall be zone selective interlock type. The farthest, downstream ground fault relay zone, sensing a ground fault, shall block all upstream relay zones for their present time delay, but shall allow each upstream relay zone to trip instantaneously for ground faults sensed in its own zone.

E. The ground fault system may be integrated into each circuit breaker with solid state trip units, in lieu of the separate specified ground fault relay and monitor panel system. The solid state circuit breaker ground fault system shall provide the identical specified operational features of the described separate system.

F. All circuit breakers located in the main switchboard shall be provided with zone selective ground fault system whether or not shown on the drawings. Provide all interconnecting

control power and interlocking wire in switchboards and between switchboards for an operational system.

2.04 MAIN SWITCHBOARDS

A. Switchboard shall be floor-mounted, dead-front, dead-rear type, front and rear aligned, self-supporting, consisting of one or more vertical sections with group mounted non-drawout circuit protective devices, instrumentation and control wiring as indicated on the drawings and as specified herein.

B. Switchboard shall be designed, built and tested in accordance with applicable portion of the latest editions of NEMA PB-2, Underwriters Laboratories No. UL-891 and the National Electrical Code.

C. Switchboard sections shall be floor standing self-supporting, of the universal frame type using dieformed, 12-gauge steel members bolted and welded together. Provide removable side and rear plates with formed edges all around. Provide ventilation openings required maintaining minimum operating temperature. Provide removable steel cover plates for all usable device spaces. Provide lifting means and provisions for moving by means of rollers or skids to installation location. Bolt individual sections together to form a single rigid switchboard assembly. Provide full height, hinged, vertical wireway metal covers, on each vertical wireway, of each distribution section of the switchboard, containing group mounted feeder protective devices.

E. Switchboard shall include, but not be limited to, the following:
   1. Underground pullsection as required by the serving utility incoming service.
   2. Metering facilities as required by the serving utility.
   3. Current transformer space.
   4. Main disconnects.
   5. Distribution and feeder circuit protective devices.
   6. Owner metering (where indicated on drawings).
   7. Bussing, incoming utility compliant and distribution.

2.05 DISTRIBUTION SWITCHBOARDS

A. Switchboards shall be floor mounted, dead-front, dead-rear type, front and rear aligned, self-supporting, consisting of one or more vertical sections with group mounted circuit protective devices, instrumentation and control wiring as indicated on the drawings and as specified herein. Switchboards shall comply with U.L. Standard #UL-891.

B. Distribution switchboards shall include but not be limited to the following:
   1. Main disconnects (where indicated on drawings).
   2. Feeder protective devices.
   3. Owner metering (where indicated on drawings).
   4. Bussing.

C. Switchboard sections shall of the universal frame type using dieformed, 12 gauge steel members bolted and welded together. Provide removable side and rear plates with formed edges all around. Provide ventilation openings required maintaining minimum operating temperature. Provide removable steel cover plates for all usable device spaces. Provide lifting means and provisions for moving by means of rollers or skids to installation location. Bolt individual sections together to form a single rigid switchboard assembly. Provide full height, hinged, vertical wireway metal covers, on each vertical wireway, of each distribution section of the switchboard, containing group mounted feeder protective devices.

2.06 METERING

A. General

1. The meters shall be microprocessor controlled, digital, multi function measuring and indicating meters. The meter measurement sensing method shall be true RMS. As manufactured by Electro Industries Model DMMS300, Square D, General Electric, Westinghouse or equal.
2. Meter face size approximately 4.5" x 4.5". Overall depth approximately 8.0". Semi flush mounting, self contained, dust proof, insulating electrical housing.
3. Ambient temperature operating ranges 0 degrees Centigrade to 55 degrees Centigrade.
4. The meter shall be rated to accommodate single phase and "DELTA" or "WYE" three phases, direct voltage connection up to 600 volts A.C.
5. The meter shall accommodate input connection through potential instrument transformer (P.T.) for voltages in excess of 600 volts. Meter burden shall not exceed 6.0 volt amperes.
6. The meter shall be rated to accommodate input connection through instrument current transformer (C.T.) up to 12,000 amperes, with a secondary C.T. current up to 10 ampere.
7. The meter scales shall be field programmable for any C.T. and P.T. ratios.
8. Provide a meter on the secondary side of the unit's substation and as indicated on the drawings.

B. Meter Indications

1. Meter indications shall be alpha numeric, LED display type, and 0.56" minimum character height. Meter indications shall simultaneously display the numerical value(s) being measured and the name of the measured value (i.e. "1586329 TOT. KWH" etc.). Meter display update time one second.
2. Minimum meter display operating life shall be 100,000 hours.
3. Meter withstand ratings:
   a. Continuous 200% of rating.
   b. Surge 10 times rating for 3 seconds.

C. Meter Monitoring and Measurement Range

1. The meter shall provide multi function monitoring for all combinations of phase to phase and each phase to neutral of the following parameters in a single self contained digital meter unit;

	Measurement Indication	Accuracy	Resolution	Range
a.	Kilowatts	0.5%	0.1%	0 to 1,000,000
b.	Kilowatt Hours	0.5%	1KW Hr	0 to 1,000,000,000
c.	Kilowatts Max-Min Demand	0.5%	0.1%	0 to 1,000,000
d.	Kilovolt Ampere Hours	0.5%	1KVA Hr	0 to1,000,000,000
e.	Kilovolt Ampere Reactive	0.5%	0.1%	0 to 1,000,000
f.	Kilovolt Amperes	0.5%	0.1%	0 to 1,000,000
g.	Power Factor	1.0	1.0%	1.0 to + 0.5
h.	Ampere	0.35%	0.1%	0 to 10,000
i.	Volts	0.35%	0.1%	0 to 100,000
j.	Frequency	0.02HZ	0.01HZ	10HZ to 125HZ
k.	Total Harmonic Distortion Current & Voltage Input to 31st Harmonic.	0.5%	0.2%	0 to 100%

2. The measurement indications shall display continuously in sequence; by individual continuous measurement; or no display (display-off) when programmed from the meter front control panel.
3. The minimum and maximum average time range shall be adjustable from instantaneous through 9999 seconds. The average time range shall be programmable from the meter front control panel to provide an instantaneous and average over time of any meter measurement indication, in any combination of measurement indications.
4. The minimum and maximum for each measurement indication shall be stored in internal memory and displayed on the alpha numeric meter display when requested from the meter control panel by the operator.
5. The meter shall store in non-volatile internal memory the following information. The stored data shall be retained even during a power failure to the meter. The information shall be recalled to the meter display from the meter front control panel:
   a. Meter preset program parameters.
   b. Maximum and minimum measurement indications.
   c. Total kilowatt-hours.
   d. Total kilovolt ampere-hours.
   e. Kilowatt demand.

D. Meter Programming and Control
1. A control panel on the front of the meter shall provide user access to all meter displays, functions and programming features. A password protection entered from the front control panel shall be provided prior to allowing any programming or set point changes to the meter.
2. The meter shall provide "data logging", monitoring and communications for each respective circuit breaker located the same equipment at the meter. The meter shall also provide password-protected software programming of circuit breaker operating parameters, and monitoring characteristics.

E. Communications Port On Meter for 2-Wire or 4-Wire Connection, EIA RS-485

2.07 MISCELLANEOUS INSTRUMENTS

A. Instrument and Control Transformers: ANSI C57.13 and NEMA ST20 as applicable. Transformers shall be specifically designed for use on respective protective relay or metering schemes utilized.

B. Current transformers meter/relay grade shall be multiratio tap, tap setting as indicated on drawings, (minimum of three field adjustable tap settings) with 5 amp secondary, insulation class, 600 volt, 60 hertz, single ring type, and shall have an accuracy classification of 0.3 with the burden of B.01, B.02 and B.03.

C. Control and transfer switches shall be of the rotary, oil-tight multiposition, cam-operated, multi-stage type, with dust cover and silver-to-silver contacts rated 600 volts, 20 amp and adequate for the duty performed in excess of 10 amp. Equip each switch with engraved plastic escutcheon nameplate identifying its function and position.

2.08 CONTROL WIRING

A. Terminal blocks with barriered terminals shall be provided for all control wiring terminator points. Control wiring shall be run in horizontal and vertical, isolated, internal metal wireways and shall be carried across hinges in laced bundles. Wire terminators shall be crimp-on type spade terminal

B. Secondary control wiring shall be minimum of 14 AWG stranded copper type SIS 600-volt insulation.

C. Control circuits shall have circuit number tags at each termination or break in the wire to match circuit numbers on terminal strips and control wiring diagrams.

PART 3 - EXECUTION

3.01 Install switchboards in accordance with manufacturer's written instructions and applicable portions of NECA's "Standards of Installations" for switchboards and motor control centers.

3.02 Bolt switchboards to floor and wall where wall exists. Where units are free standing provide preformed steel channel or angle iron bracing to nearest wall or building structural member. Switchboard anchoring shall be designed for a 1.0 gravity lateral acceleration of the equipment. Submit structural calculations and details.

3.03 TESTING (ADDITIONAL REQUIREMENTS)

Adjustable settings shall be set and tested after the equipment installation is complete, for proper operation at set pickup and/or drop-out points, by an independent test laboratory. Testing shall comply with the equipment manufacturer recommendations. Submit three copies of all test results to OWNER's Representative. Correct any deficiencies and retest.

3.04 IDENTIFICATION (ADDITIONAL REQUIREMENTS)

A. Provide a red and white Bakelite nameplate with 1/2" high letters in each section fastened to face of dead-front plate, to read: "DANGER 480 (actual volts) VOLTS, KEEP OUT, AUTHORIZED PERSONNEL ONLY".

B. Manufacturer shall stencil the equipment name on each device and equipment section to correspond to the identification of the drawing.

C. Devices mounted in equipment controlling protective devices shall be provided with nameplates indicating device controlled or monitored.

END OF SECTION

SECTION 16480

MOTOR CONTROL EQUIPMENT

PART 1 - GENERAL

1.01 SCOPE

A. Work Included: All labor, materials, appliances, tools, equipment necessary for, and incidental to, performing all operations in connection with furnishing, delivery and installation of the work of this Section, complete, as shown on the drawings and/or specified herein. Work includes, but is not necessarily limited to the following:
   1. Examine all other specification sections and drawings for related work required to be included as work under Division Sixteen.
   2. General provisions and requirements for electrical work.

1.02 SUBMITTALS

A. Provide schematic "ladder-type" logic control wiring diagrams and "point-to-point" control wiring diagrams showing the control system for HV/AC equipment and other electrical equipment.

B. Provide nameplate engraving schedule.

C. Submit full-scale time/current transparencies on log/log paper for all fuses, circuit breakers, ground fault system devices, and relays.

PART 2 – PRODUCTS

2.01 GENERAL

A. Division 15000 HVAC/Plumbing

Refer to Division Fifteen Mechanical and Plumbing Contract Documents and shop drawings for additional electrical work and material requirements.
   1. Provide all control devices including timeswitches, relays, auxiliary contacts, voltage transformers and interlocks.
   2. Provide all raceways, conduit wire, circuits, outlets and interconnections of starters as required for HVAC and Plumbing systems.

B. Special Considerations
   1. Mount all auxiliary relays and timeswitches in an isolated compartment inside motor control equipment unless otherwise indicated.
   2. Whether or not shown on mechanical and plumbing Contract Documents and/or control schedules, where motors are controlled by external devices (i.e., thermostats, relays, float or pressure switches, etc.) or interlocked with other motors, provide each magnetic motor starter with a "Hand-Off-Auto" selector switch in starter cover. Other magnetic motor starters provide a "Start-Stop" push-button station in starter cover.
   3. Equipment shall be constructed and tested to comply with seismic zone 4 earthquake requirements.
   4. Motor starters, motor controllers and circuit feeder tap devices for motor circuits shall be rated and labeled for control of all electric motor design types A,B,C,D, and E pursuant to the requirements of the NEC

2.02 MANUAL MOTOR STARTERS

A. Provide flush or surface mounting manual motor starters with number of poles and size of thermal overload heaters as required for the motor being controlled (equipped with overload heaters, one for each motor lead). Back boxes shall be supplied with all flush mounting starters, whether they are toggle type requiring only a 4" square outlet box or the larger type requiring a special box. Provide cover designed to accept the particular unit.

B. Unless otherwise noted on the drawings, all manual starters for single phase motors, smaller than 1 h.p. shall be the compact toggle type. Manual starters for all single phase motors, 1 to 5 h.p. and all three phase motors up to 5 h.p. shall be the heavy-duty type.

C. Where manual motor starter is shown with pilot light, the pilot light shall be installed in a separate outlet box adjacent to the starter outlet with engraved nameplate to indicate function of pilot light. Pilot lights shall be push-to-test style.

D. Motor starters as manufactured by: General Electric, Westinghouse, Square D, Cutler-Hammer, Allen Bradley or equal.

2.03 FEEDER TAP DEVICES

A. General
   1. Feeder tap devices shall be coordinated with the motor starter unit's electrical and mechanical characteristics. Operating handle shall be accessible and operable from the unit front with positive visible indication of the on, off and tripped operating handle positions.
   2. Feeder tap devices shall have a short circuit and motor locked rotor interrupting capacity, series rated with the respective motor starter of not less than the maximum available fault current at the device as indicated on the drawings, but in no case shall the interrupting capacity be less than 30,000 ampere symmetrical interrupting for 480/277 volt devices and 42,000 ampere symmetrical for 240 volt or 208/120 volt devices. Provide four key interlocking and padlock-off devices on each feeder tap unit.
   3. Feeder tap device (i.e. circuit breakers, switch and fuse or motor circuit protector) shall be as indicated on the drawings. Where feeder tap device type is not indicated, provide circuit breaker type device. Circuit breakers shall provide time overcurrent and instantaneous circuit protection. Motor circuit protectors shall provide instantaneous magnetic only circuit protection. Feeder tap devices shall be UL component listed and rated with the respective motor starters.
   4. Feeder tap device shall provide an auxiliary contact to automatically connect and disconnect control power when the feeder tap device is open, tripped or closed.

B. Feeder tap devices shall be as indicated on the drawings:
   1. Circuit breaker feeder tap
      a. Circuit breakers shall employ a stored energy, quick make-quick break, and trip free operating system on each phase, with common trip. Breakers shall comply with UL 489 and NEMA AB1 latest revisions. Circuit breakers noted as "100%" on the drawings shall be rated to carry the breaker full rated (100%) ampere load continuously.
      b. Performance requirements for circuit breakers conforming to one or more of the following applications:
         - Smaller than 600 ampere frame size.
         - 400 ampere and smaller trip.
         - 225 ampere and larger frame size.
         - Larger than 100 ampere trip.

1) Circuit breaker shall be molded case thermal-magnetic or solid-state trip. Thermal-magnetic circuit breakers shall be furnished with field adjustable, instantaneous magnetic trip element.
2) Solid state trip breakers shall conform to the requirements described for solid state breakers larger than 400 ampere trip except, only the following field adjustments are required;
   a) Ampere setting adjustable minimum range of 80% thru 100% of full load trip rating.
   b) Short time pickup adjustable minimum range of 2 times thru 8 times of the ampere setting.
   c) Fixed or field adjustable instantaneous trip. (Circuit breaker shall incorporate adjustable instantaneous trip settings to allow coordinated instantaneous trip settings when protecting energy efficient motors.)

c. Performance requirements for circuit breakers conforming to the following applications:
   - 100 ampere frame size and smaller.
   - 100 ampere and smaller trip.
   1) Circuit breaker shall be molded case thermal-magnetic trip.

2. Motor Circuit Protector (MCP) feeder tap:
   a. MCP shall comply with UL 489 and IEC 157-1 and shall be component listed and rated with the motor starter.
   b. The MCP shall be toggle handle operated with gang operated, quick-make, quick-break overcenter switching mechanism, mechanically trip free from the handle.
   c. Enclosed in a high strength glass polyester molded case. Contacts shall be of nonwelding silver alloy. Arc extinction shall be accomplished by means of arc chutes.
   d. A manual push-to-trip button shall be provided for manual exercising of the trip mechanism.
   e. Each pole of the MCPs shall provide instantaneous short circuit protection by means of a field adjustable magnetic-only element.
   f. The MCP mechanism shall be the transient inrush suppresser type appropriate for the protection of energy efficient motors.
   g. Where current limiting motor circuit protectors are indicated, comply with "CLCB" requirements, except provide magnetic only instantaneous trip elements without long time and short time trip elements. MCPs short circuit current limiters, shall be fully coordinated with the MCP so that the MCP will open all three phases if the limiter operates. Current limiters shall be so constructed that an identical or similar limiter having the same interrupting capacity can only replace them.

2.04 MOTOR STARTERS - 50/60HZ A.C. INDUCTION ELECTRIC MOTORS

A. General
   1. motor starters shall be horsepower rated for the motor connected to the starter, air insulated, with NEMA rating.
   2. Motor starter coils and controls shall be designed to operate on the control voltage indicated on the control diagrams and specifications. The motor starters shall reliably pick-up and seal-in at 80% thru 110% of their coil control voltage.
   3. Under voltage release for motor starter coil circuit shall automatically drop motor starter off the line when the line voltage drops below normal operating voltage. Under voltage release shall be field adjustable 80% to 95% of nominal voltage with field adjustable dropout delay 0.1 to 3 seconds minimum for starters larger than NEMA size 1. The under voltage release shall reset automatically when line voltage level returns too normal. The reset time delay shall be a 0.1 to 60-second field adjustable time range for starters larger than NEMA size 1.

4. Each motor starter control circuit shall be independently fused.
5. Three phase motor starters controlling three phase motors, 5 horsepower and larger shall provide integral motor single phasing protection. The starter shall automatically "open", turn off electrical power to the connected motor in the event of the loss of one or more circuit phases, lock out and require manual resetting of the single phase protection to restart the magnetic motor starter. Provide single-phase annunciator. Provide adjustable time delay, minimum range 0.1 to 3 seconds for initiating single phase shut down.
6. Starter units shall be equipped with individual control power transformers (grounded type) with secondary and primary control power fuses. One secondary lead shall be grounded in the unit.
   a. The unit disconnect shall be equipped with a normally open contact to isolate the control circuit from the source when the controller disconnect is open.
   b. The control power transformer VA load rating shall include the motor starter, additional internal and external control devices connected to the motor starter, to insure control power voltage drop does not exceed 5 percent of nominal rating.
7. Starter units shall be equipped with three (3) motor overload elements, one for each phase, with automatic lockout, external overload indicating flag/pilot light and manual reset external push-button. Trip rating characteristics of the overload elements shall be as recommended by motor manufacturer.
   a. Motor overload protection relays shall be bi-metal (non-melting) "heater-element" type or solid-state type, for motor starters NEMA size 1 and smaller.
   b. Motor overload protection relays for motor starters larger than NEMA size 1 shall be solid-state type.
8. Pilot light indicators shall be provided with "Push-to-Test" feature. Provide a capacitor in parallel with the starters stop-start control relay circuit, to permit the motor starter control circuit to "drop-out" (turn-off) and prevent "capacitive-holding" (capacitive coupling) on control circuits with "long" (excessive distance) control circuit wiring.
9. Each starter shall be equipped with a minimum of one (1) normally open and one (1) normally closed auxiliary spare contacts. Provide additional auxiliary control contacts for interlocking with system control circuits as indicated on the drawings and specifications. Auxiliary contacts shall be field convertible for normally open or normally closed operation. Contacts shall be rated not less than 10 amps at 120 volt 60Hz, A.C., but in no case shall the auxiliary contacts be rated for less ampere or lower voltage than the connected control circuit.
10. Motor starters larger than NEMA size 1, provide a running time meter 0 to 99999 hours minimum range, and an operations counter 0 to 9999 meter minimum operations start count range. Meters shall be field resettable with maintained memory during power outages of any length.
11. Minimum starter size shall be NEMA 1, but in no case less than indicated on the drawings or specifications.
12. Verify the exact motor connection requirements, motor locked rotor/full load current, NEMA code letter and voltage characteristics with the supplier of each motor. Motor starters shall comply with the identified requirements.
13. Each starter shall be equipped with "Hand-off-Auto" switch or stop-start push-button as required.
14. A auxiliary relay contact for remote alarm annunciation shall provide common trouble annunciation for any of the starter automatic protection systems. The alarm contact shall automatically reset when the starter is reset.
15. Provide each motor starter main "start" control relay or starter coil as applicable, with a magnetic coil auxiliary control "pilot" relay. The contacts of the auxiliary control relay shall directly control the starting, running and stopping control voltage of the motor starter main control coil circuit. The coil of the auxiliary relay shall condition and match the voltage and in rush of each motor starter to the requirements of the incoming control circuit.

16. Provide a transient surge suppressor for each motor starter coil, to limit voltage transients induced by the motor starter coil operation and to protect the motor starting circuit from voltage transients.
17. Motor starters connected to engine generator emergency power supply source (either direct connection or connection through an automatic transfer switch) shall each be provided with a field adjustable (0.1 - 180 seconds) "start" (on delay) time delay, to provide "staggered" sequenced starting of the connected motor load.

B. Full Voltage Non Reversing (Fvnr), Unless Noted Otherwise
1. Across the line full voltage magnetic electromechanical motor starter.
2. Provide FVNR motor starter for motor sizes through 50 horsepower (241 to 600 volt) and through 30 horsepower (240 volt and under) where the motor is connected to normal power utility source, unless noted otherwise on drawings.

C. Two speed Motor Starters
1. The two speed motor starters shall be compatible with the connected motor and shall provide automatic two speed control of separate high speed and low speed motor winding or consequent pole two speed motors as applicable. The starters shall be constant horsepower, constant torque or variable torque as applicable for the motor connected to the starter.
2. Low speed compelling control shall compel the motor starter to always start the motor on low speed before switching to high speed. Compelling control shall be manual switch selectable as either "in" or "out" (bypass) of the motor control circuits.

2.05 COMBINATION MOTOR STARTERS

A. General
1. Combination motor starters shall consist of a feeder tap device, motor starter and enclosure. Voltage and amperage rating as indicated on drawings.
2. Combination motor starter shall not be less than NEMA size 1, but in no case less than indicated on the drawings.
3. Unit shall be self-contained floor standing, wall mounted NEMA 1 enclosures or as indicated on the drawings. Constructed, tested and listed in accordance with NEMA, ANSI and UL standards.
4. Combination motor starters as manufactured by General Electric, Westinghouse, Square D, Cutler Hammer or equal.
5. Provide incoming line and outgoing load terminations, size and capacity to match connections shown.

B. Construction
1. NEMA styles metal enclosed, with full height hinged access door. 12-gauge welded frame members and 14 gauge panel members. All parts shall be removable and accessible from the front for ease of maintenance and rearrangement.
2. Provide removable lifting points and permanent anchor mounting points on the enclosure.
3. Hinged doors shall be mounted with removable pin hinges and secured with quarter turn indicating fasteners. A door interlock with manual defeat override shall prevent access to unit interior when the feeder tap device is in the "on" position.
4. Each metal surface shall be phosphatizing prime rust inhibitor painted and baked enamel finish painted manufacturer's standard color.

C. Combination Motor Starter Short Circuit Coordination Protection
1. The combination motor starter shall be constructed and tested to comply with the following requirements.

2. Type 1 coordination:
   Under short circuit conditions the contactor/motor starter shall cause no danger to persons or installation. Continued re-use shall be permitted after service, repair or replacement of parts.

D. Energy Efficient Motor Protection
   1. Where a combination motor starter is connected to a high efficiency motor, provide the following modifications to the starters or circuit disconnects. The modification shall prevent unnecessary tripping from locked rotor high inrush motor starting current:
      a. Circuit breaker or MCP short circuit protection - Provide circuit breaker/MCP with adjustable magnetic current trip for high inrush motor starting current, or adjustable time delay trip for high magnetic current motor inrush damping.

2.06 WEATHERPROOF MOTOR CONTROL UNITS

A. Motor control units indicated as weatherproof (W.P.) or outdoors shall be NEMA 3R, non walk-in, and tamper resistant construction. Provide full height hinged doors with provisions for padlocking the doors in the closed position.

B. Each individual combination motor starter, shall be provided with a nominal 150 watt sealed, resistance type, anti-condensation heater in each section. Heaters shall be controlled automatically by Thermostats and humidistats. A circuit breaker shall be provided to supply buss voltage to the heaters, all prewired by the Manufacturer.

C. Finish shall be electrostatically applied finish paint over iron oxide rust inhibitor primer. Finish color shall be [manufacturers standard color], [olive green Munsel #7GY3.29/1.5]. The bottom side and bottom 6 inches of floor standing equipment shall be coated with 4 MIL minimum thickness rust inhibitor undercoating over finish paint, on all interior surfaces. Finish withstand test without face corrosion or blistering:
   1. Salt spray withstands - 2000 hours ASTM B117.
   2. Humidity withstands - 750 hour ASTM D2247.

D. Exposed hardware and hinges shall be Stainless Steel type 302 or 304, tamper resistant.

PART 3 - EXECUTION

3.01 COMBINATION MOTOR STARTERS

A. Install motor control equipment in accordance with manufacturer's written instructions and applicable portions of NEMA "Standards of Installations" for switchboards and motor control centers and individual motor starters.

B. Bolt motor control equipment to floor and wall where wall exists. Where units are free standing provide preformed steel channel or angle iron bracing to nearest wall or building structural member. Motor control equipment anchoring shall be designed for a 1.0 gravity lateral acceleration of the equipment. Submit structural calculation and details.

3.02 IDENTIFICATION

A. Provide a red and white Bakelite nameplate with 1/2" high letters fastened to face of dead-front plate, to read: "DANGER 480 (actual volts) VOLTS, KEEP OUT, AUTHORIZED PERSONNEL ONLY".

B. Manufacturer shall stencil the panel number and name of the connected motor circuit on each device and equipment section to correspond to identification on the drawing.

C. Identification plates and numbers shall be attached with screws or twist lock fasteners. Adhesive attachment of any kind as the only method of attachment shall not be used.

3.03 SETTINGS AND ADJUSTMENTS

A. Program and set control function sequences, time delays, and protective device settings for correct system operation.

B. Test all timing, control sequences and motor rotation direction for proper operation. Correct deficiencies and retest until proper operation is confirmed.

END OF SECTION