SECTION 16480 - MOTOR CONTROL

City of San Diego, CWP Guidelines

PART 1 - GENERAL

1.1 WORK OF THIS SECTION

A. The WORK of this Section includes providing group-mounted and unit motor control as required for motors provided.

B. If motors furnished are different from those indicated, then starters, overload elements, and branch circuit protection shall be adjusted and coordinated as required to control and protect the motors provided.

1.2 RELATED SECTIONS

A. The WORK of the following Sections applies to the WORK of this Section. Other Sections of the Specifications, not referenced below, shall also apply to the extent required for proper performance of this WORK.

1. Section 16050 Basic Electrical Materials and Methods
2. Section 16300 Medium Voltage Distribution
3. Section 16400 Low Voltage Electrical Service and Distribution
4. Section 16431 Short-Circuit and Coordination Report
5. Section 16030 Electrical Tests

1.3 CODES

A. The WORK of this Section shall comply with the current editions of the following codes as adopted by the City of San Diego Municipal Code:

1. National Electrical Code (NEC) NFPA 70

1.4 SPECIFICATIONS AND STANDARDS

A. Except as otherwise indicated, the current editions of the following apply to the WORK of this Section:

1.	NEMA ICS-1	General Standards for Industrial Controls
2.	NEMA ICS-2	Industrial Control Devices, Controllers, and Assemblies
3.	UL 845, 489, 508	Electric Motor Control Centers, Molded Case Circuit Breakers, and Industrial Control Equipment

1.5 SHOP DRAWINGS AND SAMPLES

A. The following shall be submitted in compliance with Section 01300:

1. Shop drawings of all motor control centers and components.

a. Shop drawing submittals shall comply with the "Shop Drawings and Samples" paragraph of Section 16050. The submittal shall also include conduit entrance locations and requirements; nameplate legends; size and number of bus bars per phase [neutral] and ground; electrical characteristics including voltage, frame size and trip ratings of overcurrent devices, short circuit withstand ratings, and protective device time-current curves of all equipment and components.

2. Product data on motor starters and combination motor starters, relays, pilot devices and switching and overcurrent protective devices.

3. A wiring diagram and an elementary control diagram for each motor control center cubicle. An identifying number shall be assigned to each wire.

4. Seismic design certification and anchorage sketches in accordance with Section 16050.

1.6 OWNER'S MANUAL

A. The following shall be included in the OWNER'S MANUAL in compliance with Section 01300:

1. Spare parts data listing.
2. Source and current prices of replacement parts.
3. Recommended maintenance procedures and intervals.
4. Factory test reports.

1.7 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Motor control centers shall be stored in a clean, dry space. Maintain factory wrapping or provide an additional heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Motor control centers shall be handled carefully to avoid damage to motor control center components, enclosure, and finish.

PART 2 - PRODUCTS

2.1 GENERAL

A. Motor control center shall be a product of the manufacturer furnishing the [low voltage service disconnect switch for the facility] [main circuit breaker] [low voltage substation].

B. All similar products of the same type shall be furnished by a single manufacturer.

C. Motor control assemblies (motor control centers) shall conform to the standards for NEMA Class II, type B assemblies.

D. Components and assemblies shall comply with NEMA ICS 2.

2.2 DESIGN, CONSTRUCTION AND MATERIAL REQUIREMENTS

A. The motor control center(s) shall be 600 volt class suitable for operation on a three-phase 60 Hz system. The system operating voltage and number of wires shall be as indicated.

B. The main horizontal bus shall be copper with minimum ampacity of 600 amperes or rated as indicated. Main bus shall be copper, silver-plated and enclosed in an isolated compartment.

C. The vertical bus in each section shall consist of a single silver plated copper conductor per phase with a current capacity of not less than 300 amps. The vertical bus shall be completely isolated and insulated.

D. All power busses shall be braced to withstand [22,000] [30,000] [42,000] [65,000] [100,000] amps RMS symmetrical.

E. A continuous copper ground bus shall be provided full width at the bottom of the motor control center line-up.

F. Where indicated, fully-rated, continuous, neutral bus shall be furnished through the control center. Lugs of appropriate capacity shall be furnished.

G. A separate vertical wireway shall be provided adjacent to each vertical unit and shall be covered by hinged door. Each individual unit compartment shall be provided with a side barrier to permit pulling wire in the wire trough area without disturbing adjacent unit compartments.

H. Indoor enclosure(s) shall be NEMA type [1-gasketed] [12-industrial]. Outdoor enclosures where indicated shall be NEMA type [3R non-walk-in] [3R walk-in].

I. Motor control sections shall be nominally 90 inches high and 20 inches deep for front mounted units.

2.3 MOTOR STARTERS -- GROUP MOUNTED

A. Group-mounted starters shall be mounted in standard motor control center assemblies and arranged as indicated.

B. Each motor starter unit shall consist of a combination magnetic starter and circuit breaker all mounted in a completely enclosed cubicle. Short circuit protective device shall be a Motor Circuit Protector (MCP). Where continuous rating exceeds 400 amperes the protective device shall consist of a molded case circuit breaker with a thermal-magnetic trip unit. MCP unit shall have low level sensing and shall incorporate a device to prevent setting trip levels in excess of 1300 percent of continuous rating. Contactor circuit shall include 3-phase thermal overload protection, ambient compensated. Reset of thermal overload elements or adjustment of instantaneous trip settings shall be possible with unit door closed. Overload trip units shall be furnished to suit the nameplate full load current of the equipment installed. IEC rated starters are not acceptable.

C. Magnetic starters shall have auxiliary contacts as required by electrical motor control diagrams including one spare N.O. and one N.C. contacts. The combination motor starters shall be drawout-type for size 3 and below. The fixed-type unit assembly shall be so constructed that it can be easily removed from its panel after disconnecting the wires to the terminal block and withdrawing from the primary bus. Removal of a unit assembly shall be possible without rear access and without disturbing any other unit in the motor control center.

D. Each starter unit shall have its own control power transformer; it shall have a 120-volt grounded secondary. One secondary fuse and 2 primary fuses shall be provided. Unit

control power transformers shall be sized to accommodate the control devices indicated. Local control devices shall be mounted independently of the cover door. All starters having automatic control shall have a local "red" running lamp. All cubicle control wires shall be terminated at a disconnecting (separable) or pull-apart terminal block at the cubicle.

E. The motor control center manufacturer shall be responsible for identifying each control wire within each motor starter unit with wrap-around permanent plastic markers. Each control wire shall be as identified at both ends.

F. Motor starter units shall be NEMA size I or larger.

G. Part-winding starting units shall consist of a molded-case circuit breaker in combination with part-winding type, non-reversing magnetic starter with 6 overload relays, 3 in each winding and arranged so that each line has overload protection, [6] [8] auxiliary interlocks and one double-pole relay with 120-volt coil. The starter NEMA size shall be as indicated. The starters shall be 480-volt, 3-phase, 60-Hz, of the heavy-duty type. Timing of the starting period shall be controlled by an adjustable accelerating relay. A thermal overload reset pushbutton shall be mounted on the front of each starer compartment. Cast terminal lugs shall be furnished on each motor starter for connecting motor leads. The contactors shall operate without chatter or perceptible hum while energized. The operating coils shall be suitable for continuous operation on a [480-volt] [120- volt], AC circuit.

H. Reduced voltage auto-transformer starter unit shall consist of a molded-case circuit breaker in combination with a closed transition type auto-transformer starter with 50 percent, 65 percent, and 80 percent taps and shall be set on the 65 percent tap. The starter shall have 3 overload relays, one per phase, and shall be ambient temperature-compensated with manual reset. The auto-transformer shall include a thermal switch wired to protect the auto-transformer from overheating. Timing of the starting period shall be controlled by an adjustable accelerating relay.

I. Solid-state reduced voltage starter shall consist of a power section, a one piece printed circuit logic board and a field wiring interface terminal board. Internal construction shall consist of the following:

1. The power section shall be three-phase, 60 hertz, and rated for the HP, current, and voltage as indicated. It shall consist of three sets of back-to-back phase controlled power semi-conductors. Maximum current-limit shall be 500 percent for standard units.

2. Resistor/capacitor snubber networks shall be used to prevent false firing of SCRs due to dv/dt characteristics of the electrical system.

3. Fan cooled units shall be supplied with thermal sensors on the heat sink to trip the control protective logic for over-temperature condition. Thermal sensors shall be rated 90 degree C maximum.

4. The one piece logic board shall be mounted for easy testing, service and replacement.

5. Three-phase current sensing via current transformers for closed loop control to ensure motor stability shall be provided.

6. The logic board shall use a quick disconnect plug-in connector for current transformer inputs, line and load voltage inputs, SCR gate firing output circuits and status panel.

7. The logic circuitry shall include as a minimum:

    a. Short circuit electronic trip overcurrent protection. Time not to exceed 1/2 cycle.

    b. Inverse time running overcurrent protection.

    c. Auxiliary trip circuit.

    d. Gate firing circuit lockout protection on trip.

    e. Fault relay lockout protection.

    f. 250 percent to 500 percent current limit adjustments.

    g. Minimum and maximum voltage adjustments.

    h. Voltage stability adjustment.

    Controllers for motors larger than 200 HP shall have additional features as follows:

    a. Dwell time at current limit with ramp continuation after acceleration.

    b. Individual light emitting diodes (LEDS) to indicate run, undervoltage, phase loss, phase current unbalance, overcurrent trip, overtemperature, current limit, end of ramp and incorrect phase rotation.

    c. Single phase protection with built-in short time delay.

    d. Undervoltage protection with built-in short time delay.

8. The logic board shall include, current and motor slip sensing circuitry that will continually monitor motor load and regulate motor voltage to minimize motor kwh energy consumption.

9. External interface circuitry shall include 120 volt relay logic interface capability.

10. Tripped functions shall be designed to be cleared by removing power from the solid-state logic board.

11. The logic board shall provide phase sequence protection.

12. The solid-state logic shall provide phase sequence protection.

13. Two ground lugs shall be furnished, one for incoming and one for outgoing ground connections.

14. Power terminations shall consist of pressure type terminals for top or bottom entrance.

15. The power section for motors above 200 HP shall have metal oxide varistor (MOV) type surge suppressors across the SCRs rated 10 percent above the SCR rated voltage. The power semi-conductors shall be rated with peak inverse voltage at least 2.5 times SCR rated line-to-line voltage. Suitably rated snubbers for voltage suppression shall be included. Data shall be made available on tolerances to incoming line voltage surges or line spikes. Data shall include both magnitude and

time content of each spike (voltage peaks and volt-seconds) plus tolerance to repetitive surges.

16. 100 percent to 200 percent load running current trip adjustment.

[17. Capacitors shall be provided for power factor correction of the motors to 95 percent. Provide circuit and contactor to electrically isolate the capacitor. A timing relay shall be provided to pick up the capacitor rated contactor after the start cycle of the solid state reduced voltage starter. Provide necessary interlocking so that the capacitor is only on line when the motor is operating. Contactor and capacitor size shown is estimated. The MCC manufacturer shall obtain the recommended sizing from the motor manufacturer. Submit sizing information with documentation for review by the CONSTRUCTION MANAGER.]

J. [Motor short circuit protective devices, i.e., circuit breaker or MCP shall be fitted with a "c" contact wired to terminals to be used for remote indication of device position.]

K. Each motor control center shall be fitted with the manufacturer's nameplate which shall include the NEMA Standard electric rating and other pertinent data, including sales order number, date of manufacture, and place of manufacture.

L. "Spaces" shall be starter cubicles arranged for future addition of the door and NEMA size starter indicated on the drawings. The vertical bus shall extend to, but not be exposed within "spaces."

M. Transient surge suppressors shall be provided in each starter. Suppressor shall be encapsulated in a small module suitable for mounting directly to the starter or relay coil.

2.4 MAIN AND FEEDER CIRCUIT BREAKERS

A. Circuit breakers having a frame size of 150 amperes or less shall be molded-case type with thermal magnetic non-interchangeable, trip-free, sealed trip units. Breaker contact material shall be a non-weldable silver alloy. Breakers shall have arc-extinguishing chutes.

B. Circuit breakers with a frame size of 225 amperes to 800 amperes shall be molded case with interchangeable thermal and adjustable magnetic trip elements. Main circuit breakers with a frame size of 1000 amperes and larger shall be insulated case type fully rated circuit breakers.

C. The interrupting capacity of all main and feeder circuit breakers shall be a minimum of [42,000] [65,000] [100,000] RMS symmetrical amperes.

2.5 MOTOR STARTERS -- UNIT MOUNTED

A. Unit-mounted motor starters shall consist of individual units mounted in close proximity to the machinery controlled.

B. Magnetic starters shall be the combination circuit breaker type with cover interlocked with circuit breaker handle; unit shall have control power transformer and panel mounted control devices all as specified for group-mounted starters in motor control centers.

C. Manual starters shall have 2-pole thermal overload elements and shall have auxiliary control devices as shown. Operating handle shall be trip-free and shall be indicated "On", "Off" or "Tripped" positions.

2.6 MOTOR CONTROL CENTERS

A. Outdoor motor control centers shall be housed in a NEMA [3R-walk-in] [3R-non-walk-in] housing having a sloping roof and sufficient depth to provide clearance between the housing and control center front panel as shown on drawings. The CONTRACTOR shall:

1. Provide thermostatically controlled space heaters for each section of outdoor motor control.

2. Provide [incandescent] [fluorescent] lamp at every other vertical section; lamps shall have a control switch mounted on the motor control center interior of the outdoor enclosure.

3. Provide one convenience outlet within each motor control center.

[4. Provide control power panel, transformer and primary circuit breaker as shown. Connect motor control center accessories to control power panel.]

[5. Provide forced ventilation system to result in four air changes per minute in the motor control; provide air passages throughout control center so that all vertical sections are equally ventilated.]

6. Provide ventilation louvers at top and bottom of each vertical section; louvers shall be fitted with filters and shall be rodent and bird proof.

2.7 PREPARATION AND FINISH

A. The CONTRACTOR shall have the manufacturer of the motor control center enclosures prepare them in strict accordance with the following requirements:

1. NEMA 1 gasketed indoor assemblies shall be prepared and finished using materials and methods of the manufacturer's standard finish and colors, except that at least 2 coats of the final finish shall be applied by the manufacturer.

2. NEMA 12 industrial indoor assemblies shall be prepared and finished using materials and methods of the manufacturer's standard finish and colors, except that as many factory-applied coats as necessary of the final finish shall be applied so that average dry film thickness of the total preparation and finish coating shall be not less than 2 mils for a baked coating or 3 mils for an air-dry coating.

3. NEMA [3R-walk-in] [3R-non-walk-in] outdoor rain-tight assemblies shall be prepared and finished with a coating which is suitable for an outdoor application [in the immediate vicinity of the ocean] [in an area exposed to prevailing winds, blowing sand,] [and salt spray], as well as the deteriorating effects of prevailing corrosive conditions in a [sewage treatment] [wastewater reclamation] facility.

The average dry film thickness of the preparation and finish coating shall be not less than 2 mils for a baked coating or 3 mils for an air-dry coating. [Final finish of each outer enclosure shall be a different special color as selected by the CONSTRUCTION MANAGER.]

2.8 CONTROL DEVICES

A. **Selector Switches**: Selector switches shall be rated 10 amperes at 600 volts, shall be heavy-duty, oil-tight, shall have the number of positions and poles indicated. Each shall have a factory-engraved legend plate, as indicated.

B. **Pushbutton Switches**: The pushbutton stations shall be heavy-duty type with NEMA enclosures of the type indicated. When required, provisions shall be made for padlocking the "Stop" button. Pushbutton devices in damp or outdoor locations shall be fitted with appropriate neoprene boots.

C. **Indicating Lights**: Indicating lights shall be full-voltage, push-to-test type, and shall be heavy-duty, oil-tight as specified above for selector switches. Each shall be nickel-plated with a screwed-on glass prismatic lens approximately one-inch in diameter.

D. **Magnetic Relays**: Magnetic relays shall be machine tool type with 115-volt ac coils and 10-amp contacts, unless otherwise shown. Contacts shall be field convertible. Relays shall be base-mounted to a common mounting channel. Mounting dimensions and drilling for AC and DC relays shall be identical.

E. **Time Delay Relay**: Time delay relays shall be pneumatic on-delay or off-delay with calibrated time range dials, adjustable as indicated.

F. **Timers**: Timers shall be synchronous motor driven with a solenoid operated clutch. Timer shall be on-delay or off-delay for semi-flush panel-mounting. The timers shall be rated 120-volt, 60-Hz, with 10-amp rated contacts and with time range as indicated.

G. **Elapsed Time Meter**: Elapsed time meter (ETM) shall be non-reset type; shall register hours and tenths of an hour; shall have flush panel-mount case not less than 3 inches square; shall be suitable for operation at 120 volts, 60-Hz, AC.

H. **Terminal Blocks**: Terminal blocks for control wiring shall be molded type with barriers, rated not less than 600 volts. Crimped eyelets or approved equal shall be used on all stranded control wire wherever wires are terminated on screw terminals. White or other light-colored marking strips, fastened by screws to the molded sections at each block, shall be provided for circuit designation. Each connected terminal of each block shall have the circuit designation or wire number imprinted on the marking strip with permanent marking fluid. Provide at least 20 percent spare terminals.

[I. **Alternator Relay**: Alternator relay shall be heavy duty, industrial grade.]

2.9 FACTORY TESTS

A. The motor control centers and components shall be given manufacturer's standard electrical and mechanical production tests and inspections with complete test reports submitted to the CONSTRUCTION MANAGER for approval. The tests shall include, but not be limited to, electrical continuity check, dielectric tests for each circuit and inspection for proper functioning of all components, including controls, protective devices, metering and alarm devices.

B. Motor control centers shall be tested in accordance with NEMA ICS-2.

2.10 NAMEPLATES, TOOLS AND SPARE PARTS

A. **Spare Parts**: The WORK includes the following spare parts:

1. 1 unit control transformer for each size of magnetic starter

2. 3 bezels of each color installed in pilot indicators

3. 1 dozen panel lamps

4. 1 dozen control fuses of each size provided in the WORK

Spare parts shall be stored in tool boxes and identified with the equipment number by means of stainless steel or solid plastic name tags attached to the box.

2.11 MANUFACTURERS

A. Products of the type indicated shall be manufactured by one of the following (or equal):

1. Motor Control Centers

Westinghouse 2100 Series
Square D, Model 5
General Electric 8000 Line
Allen Bradley, Bulletin 2100

2. Manual Motor Starters

Allen Bradley Bulletin 600
Westinghouse Type MS
Square-D, Class 2510

3. Control Devices

Selector switches

General Electric Type CR104P
Square D Class 9001 Type K
Allen-Bradley, Bulletin 800H

Pushbutton switches

Allen Bradley Bulletin 800
Square D Class 9001, Type K

Indicating lamps and lamp holders

General Electric
Sylvania No. 6S6, 145 volt, clear
Allen-Bradley, 800H
Square D Class 9001

AC relays

Westinghouse Type ARD
Square D Class 8501 Type L
Allen-Bradley, Bulletin 700

DC relays

Westinghouse Type BFD
Square D Class 8501 Type H

Time delay relays

Agastat 7000 Series
Omron Type ATSS

Reset timers

Eagle Signal Division, E.W. Bliss Co., Bulletin 125
Automatic Timing and Controls, Inc., Type 305

Elapsed time meters

General Electric Type KT
Eagle Bulletin 705 Type HK

Alternator relays

Furnas 47AB10AF
Square D, Class 9039

PART 3 - EXECUTION

3.1 GENERAL

A. The CONTRACTOR shall install the motor control center in accordance with manufacturer's published instructions. Conduit installation shall be coordinated with manufacturer's as-built drawings so that all conduit stub-ups are within the area allotted for conduit. Conduit shall be stubbed up in the section which contains the devices to which conductors are terminated.

3.2 INSTALLATION

A. The motor control center shall be set level within 1/32-inch per horizontal foot. After leveling and shimming, the CONTRACTOR shall anchor motor control center to concrete pad and shall grout in place so that no space exists between the pad and support beams.

B. The CONTRACTOR shall:

1. Torque all bus bar bolts to manufacturer's recommendations; tighten all sheet metal and structure assembly bolts.

2. Adjust all MCP devices to lowest setting consistent with reliable operation under normal conditions. Verify that overload devices are proper for equipment installed;

make necessary changes in overload devices as required for motors having power factor correcting capacitors.

3. After equipment is installed, touch up scratches and verify that nameplate and other identification is accurate and in compliance with these Specifications.

C. The CONTRACTOR shall install pushbutton stations that are remote from the motor control centers, as shown on the drawings.

3.3 FIELD TESTING

A. The CONTRACTOR shall test all pilot lamp indicators and test all controls prior to plant startup.

B. The CONTRACTOR shall perform all the testing required by Section 16030.

** END OF SECTION **