SECTION 16482

MOTOR CONTROL CENTERS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes: Requirements for providing motor control centers.

B. Related Work Specified in Other Sections Includes:

1. Section 03310 - Cast-in-Place Concrete
2. Section 09900 - Painting
3. Section 16050 - Basic Electrical Materials and Methods
4. Section 16120 - Wires and Cables - 600 Volts and Below
5. Section 16170 - Adjustable Frequency Drives
6. Section 16195 - Electrical Identification
7. Section 16450 - Grounding
8. Section 16950 - Electrical Testing Requirements

1.2 REFERENCES

A. Codes and standards referred to in this Section are:

1. IEEE C37.90 - IEEE Standard for Relay and Relay Systems Associated With Electrical Power Apparatus
2. NEMA ICS 2 - Industrial Control Devices, Controllers and Assemblies
3. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
4. UL 486A - Wire Connectors and Soldering Lugs for Use With Copper Conductors
5. UL 845 - Motor Control Centers

1.3 SYSTEM DESCRIPTION

A. Design Requirements: Provide equipment capable of operating in an ambient temperature range of 0 to 40 degrees C and humidity of up to 90 percent noncondensing.

1. Provide motor control centers designed for 480-volt, three-phase, three-wire, 60-hertz operation.

2. Design all control devices in the center for operation at 120-volts, 60-hertz, unless specifically noted otherwise.

3. Manufacture all control equipment and devices to meet the requirements of the 600-volt insulation class.

4. Provide motor control centers to include the indicated number of 21-inch deep sections and the components arranged as shown.

5. Arrange the equipment for convenient and ready accessibility from the front for inspection and maintenance of devices, terminals and wiring.

1.4 SUBMITTALS

A. General: Provide all submittals, including the following, as specified in Division 1 and Section 16050.

B. Product Data and Information: Provide catalog data for all associated equipment and devices.

C. Shop Drawings: Provide shop drawings for motor control centers to include the following:

1. Outline drawings showing dimensions, arrangement, elevations, identification of components and a nameplate schedule for all units.

2. Bill of materials including manufacturers' name and catalog number.

3. Interconnecting wiring diagrams, where required.

4. Individual schematic and wiring diagrams for each compartment.

5. One-line diagrams.

Obtain and enter full performance details on all motors and other equipment being served on the above drawings.

D. Quality Control: Provide the following test reports and certificates as specified in Division 1:

1. Certified Shop Test Reports for motor control centers and related components. Provide a minimum of 15 days written notice prior to shop tests.

2. Detailed field test reports of all tests indicating test performed as specified, discrepancies found, and corrective action taken.

3. Provide manufacturer's certificates for motor control centers.

E. Operation and Maintenance Manuals: Provide operation and maintenance manuals as specified in Division 1.

1.5 QUALITY ASSURANCE

A. Codes: Manufacture all motor control centers in accordance with NEMA IC-S2, and UL Standard No. 845.

1. Manufacture and install each motor control center in accordance with the NEC and local codes.

B. Provide a UL Label on each vertical section of each motor control center.

1.6 DELIVERY, STORAGE AND HANDLING

A. General: Deliver, store, and handle all products and materials as specified in Division 1.

B. Shipping and Packing: Provide all structures, equipment and materials rigidly braced and protected against weather, damage, and undue strain during shipment.

C. Storage and Protection: Store all equipment and materials in a dry, covered, heated and ventilated location. Provide any additional measures in accordance with manufacturer's instructions.

1.7 SPARE PARTS

A. General: Provide the following spare parts:

1. One current transformer of each type and each rating.

2. One set of contact tips, control power transformers and operating coils for each six or less of each size of motor starter.

3. One auxiliary contact unit or one set of auxiliary contact tips for each six or less motor control units.

4. Ten percent but not less than two complete control, latching and timing relays of each type used in motor control centers.

5. One complete reset and repeat cycle timer of each type and rating used in motor control centers.

6. Two complete replacements of overload heater units for each catalog number installed in motor control centers and motor starters.

7. Two complete replacements of all indicating lamps and fuses used in the installation.

8. One complete magnetic starter with motor circuit protector for each size required.

9. Two sets of replacement indicating light color lenses of each color furnished.

10. One circuit breaker test unit.

11. Two control stations of each type provided.

12. Three of each type and kind of manual starter.

B. Packaging: Pack spare parts in containers bearing labels clearly designating contents and related pieces of equipment. Deliver spare parts in original factory packages. Identify all spare parts with information needed for reordering.

## PART 2 PRODUCTS

### 2.1 MANUFACTURERS

A. Acceptable manufacturers are listed below. Other manufacturers of equivalent products may be submitted.

1. Motor Control Centers, Manual Starters and Control Stations:

   a. Westinghouse Electric Corporation
   b. General Electric

2. Control Relays:

   a. Westinghouse Electric Corporation
   b. Square D Company

3. Timing Relays:

   a. Agastat 7000 Series
   b. Eagle Signal

4. Reset and Repeat Cycle Timers:

    a. Eagle Signal
    b. Automatic Timing and Controls

5. Alternators

    a. Autocon Class 7101
    b. Healy-Ruff

6. Metering and Protection Systems:

    a. Westinghouse IQ Data Plus
    b. Multilin
    c. Time Mark Model 264

7. Power Transducers:
    a. Scientific Columbus Type Exceltronic
    b. Rochester Instrument Systems

## 2.2 MOTOR CONTROL CENTER

A. Basic Structural Components: Provide totally enclosed, dead-front, rigid, NEMA 12, gasketed, self-supporting and freestanding structures.

1. Construct the various sections from steel sheets not less than 3/32-inch thick, formed into proper shape, suitably reinforced and welded. Grind all internal welds smooth and round off all corners to give a neat and pleasing appearance.

2. Provide steel bottom plates in each compartment section.

3. Cover the rear of each structure with easily removable steel panels for access to the vertical buses.

4. Design both ends of a completely assembled center so that extensions can be easily added in the future.

5. Provide hinges, screws, bolts, circuit breaker operating mechanisms, nameplate mounting screws and other metallic appurtenances with a noncorrodible metal covering.

6. Install full height steel barriers on each side of the tie breaker structure to prevent the passage of flames and ionized gases.

7. Provide each motor control center with a three-phase bus compartment at the top and a conduit and cable compartment at the top and bottom.

8. Design the cable compartments to run the full length of the motor control center.

9. Provide access to cable compartments by means of removable steel plates.

10. Design each structure with a vertical wiring space between the starter cells and side sheet for unit wiring.

11. Equip the vertical wiring space with cable supports to hold the cables and wiring in place.

B. Bus Requirements: Provide buses of silver plated copper bars across each structure, sized in accordance with UL temperature rise of 50 degrees C based on a 40-degree C ambient temperature.

1. Install 600-ampere minimum, main horizontal bus, unless otherwise shown.

2. Support all bus bars in each structure by means of bus supports fabricated from an insulating material.

NOTE: Select cable or bus bar for main and tie breaker connections to main bus.

3. Connect the horizontal bus to the incoming line circuit breakers and from both sides of the tie breaker with copper (cables) (bars), securely fastened in place.

4. Provide vertical three-phase copper bus of sufficient size to carry loads served.

5. Insulate main and vertical buses over their entire length. Install insulated covers over all bolted connections.

6. Separate the bus bar compartments from breaker and controller cubicles by insulated barriers or steel plates.

7. Provide a 300-ampere uninsulated copper grounding bus with lugs for connections to the plant grounding system in the bottom of each motor control center.

8. Brace all bus work suitably to withstand a minimum of 65,000 rms amperes symmetrical short circuit current. Substantiate construction by a certified laboratory test covering units of similar construction.

9. Design back-to-back motor control centers with a common main and vertical buses.

C. Individual Units: Fabricate motor control or circuit breaker units in combinations of not less than 12-inch modular heights.

1. Provide units of the plug-in or nonremovable type in accordance with the manufacturer's standard for type and size of controller.

2. Provide plug-in units with silver-plated, pressure-type line disconnecting stabs of high strength copper alloy. Hold each plug-in unit in place and arrange the units such that they can be removed or remounted readily without access to the rear of the structure.

3. Design each unit to be totally enclosed and effectively baffled to isolate ionized gases that may occur within the unit. In addition, ventilate each unit so that it can be located anywhere within the structure using the same overload heaters for the same load.

4. Provide automatic shutter mechanism to cover the vertical bus stub area when a unit is removed.

5. Provide spaces for future equipment in unit structures with blank hinged doors and removable metal barriers for isolation of the vertical buses.

6. Construct doors to be drip-proof and dust-tight. Provide all doors with hinges and screw fasteners for holding the doors closed. Fabricate each door as a part of the structure and not part of the unit.

7. Equip the doors for motor control compartments with a motor circuit protector operating mechanism, thermal overload relay reset mechanism, controls and indicating lights and other required devices as shown.

8. Equip the doors for branch feeder equipment with a circuit breaker operating mechanism.

9. Provide mechanical interlocks between the compartment door and circuit breaker operating mechanism to prevent opening of the door unless the breaker is in the OFF position, and to prevent closing the breaker unless the door is fully closed.

10. Arrange the circuit breaker operating mechanism or handle to be padlocked in the OFF position with room for a minimum of three padlocks.

11. Design and wire each unit so that all devices are serviceable from the front, without provisions for rear access.

12. Install all control power transformers, relays, timers, alternators and accessories in each unit as shown or specified.

D. Wiring:

NOTE: Revise if NEMA Type C wiring is required.

1. Provide NEMA Class II Type B wiring for the motor control centers, including internal interlock and internal wiring between controller units and devices.

2. Provide internal wiring runs for interconnecting units with stranded switchboard wire having 600-volt rated, flame-resistant, type SIS insulation. Use No. 14 AWG wire for control interconnections. Provide power connections as required for the service.

3. Provide wire markers at each end of all wires.

4. Where wiring connections are made to equipment mounted on hinged doors, provide connections with extra flexible wires suitably cabled together and cleated.

5. Provide wiring of all control connections to individual terminal blocks at each motor starter. Locate terminal blocks for front access.

6. Provide interlocking wiring between units of a motor control center or between units of grouped centers as internal wiring with terminals provided for external connections.

7. Provide sufficient terminals for all devices external to the motor control center.

E. Magnetic Starters: Provide 480-volt, 3-phase, 60-hertz across-the-line combination motor circuit protector magnetic starters with individual control power transformers.

NOTE: Add reduced voltage starters if required.

1. Provide full voltage nonreversing, full voltage reversing, full voltage two-speed nonreversing two-winding, and full voltage two-speed nonreversing one-winding starters as required.

2. Provide starter contacts of the replaceable spring-loaded wedge type with silver-cadmium oxide plated contact surfaces. Provide replaceable coils of the epoxy sealed type.

3. Thermal Overload Elements: Provide each magnetic contactor starter unit with a Class 20 thermal overload element and all required accessories. Provide size five and larger starters with current transformer operated overload relays.

   c. Provide overload relays of the bimetallic type with adjustment knobs which allow plus or minus 15 percent adjustment of the nominal heater rating.

   d. Supply and adjust overload relays to match the associated motor nameplate running current rating. Size the overload relays after approval of the corresponding motor.

   e. Provide a single-pole, double-throw alarm contact for each overload relay.

4. Replaceability: Ensure that all component parts of the starters are replaceable by means of simple methods.

5. Equip starter with all required auxiliary contacts.

F. Motor Circuit Protectors: Provide a motor circuit protector for each combination starter using molded case, air-break type designed for 600-volt, 60-hertz service with an interrupting capacity of 65,000 rms symmetrical amperes at 480 volts. Provide three-pole motor circuit protectors with magnetic adjustable trip units actuating a common tripping bar to open all poles when an overload or short circuit occurs. Provide motor circuit protectors with no thermal elements. Provide magnetic trip units capable of being set from 700 to 1,300 percent of the motor full load amperes.

G. Contactors: Provide NEMA sized, 30 ampere minimum, contactors for electric heating and other non-motor loads similar to the motor starters except without overload relays or heaters.

H. Feeder Circuit Breakers: Provide molded case type two- or three-pole feeder circuit breakers as shown, with a minimum voltage rating of 600-volt ac.

6. Interrupting Ratings: Provide an interrupting capacity of 65,000 rms symmetrical amperes at 480 volts. Base interrupting rating on the IEEE and NEMA Standard duty cycle for this class of equipment. Provide continuous current ratings of the circuit breakers as required.

7. Provide circuit breakers trip units as follows:

   f. Provide individual thermal-magnetic trip units for all frame sizes 600 amperes and smaller.

   g. Provide solid-state trip units for all frame sizes above 600 amperes.

   h. Design trip units to actuate a common tripping bar to open all poles when an overload or short circuit occurs on any one.

   i. Use trip elements with inverse time tripping and instantaneous tripping at about ten times the normal trip device rating.

   j. Design circuit breakers with trip-free handles.

I. Main and Tie Circuit Interrupters: Provide all main and tie circuit interrupters rated as shown, of equal construction to the feeder breakers, and with the following additional features:

   1. Adjustable ground fault pickup and delay setting for breakers with trip ratings of 1,000 amperes or larger.

   2. Auxiliary normally open and normally closed contacts and tripped alarm contacts.

   3. Install key interlocks as shown.

J. Adjustable Frequency Drives: Provide adjustable frequency drives meeting the requirements of Section 16170.

K. Instrument Transformers: Provide transformers in an accuracy class to meet the requirements of ANSI Standards, and for the secondary burdens connected to the transformers.

   1. Provide dry wound type current transformers with fully coordinated insulation for 600-volt insulation class.

   2. Use window type current transformers for ground sensing where shown.

   3. Provide potential transformers rated at 480 to 120 volts.

L. Instruments: Furnish flush- or semiflush-mounted instruments with cases of similar design in accordance with the following:

   4. Antiglare glass fronts.

5. Antiparallax scales consisting of white faces with black numerals and markings.

6. Length of the scale arc not less than 7 inches.

7. Approximately 4-1/2 inches square.

8. Provide instruments scales based on the instrument transformers provided, unless otherwise specified.

9. Accuracy: One percent of full scale values.

10. Provide drawout watt-hour meters with test disconnect facilities.

M. Power Transducers: Furnish voltage, current, watt, var, frequency and power factor transducer in accordance with the following:

1. Solid-state devices.

2. Output: 4-20 mA into a 750-ohm load.

3. Provisions for zero and span adjustment with 0.25 percent accuracy.

4. Input power: Operate on external 120-volt ac, single-phase, 60-hertz or derive their power supply from input signals.

5. Calibrate power factor transducer between 50 percent lag and 50 percent lead.

6. Use watt and var transducers designed for 3-phase, (3) (4)-wire system.

N. Microprocessor-Based Metering and Protection System: Furnish a microprocessor-based metering and protection system consisting of the following features:

1. 6-digit LED indicating readout.

2. UL recognized component meeting IEEE C37.90.

3. Housed in a NEMA 12 or 3R enclosure suitable for door mounting.

4. Derive control power from metered line.

5. Auto ranging metering of the following values:

   k. AC amperes in each phase, 1 percent accuracy
   l. AC voltage, phase-to-phase, phase-to-neutral, 1 percent accuracy
   m. Watts, 2 percent accuracy
   n. Vars, 2 percent accuracy
   o. Power factor, 4 percent accuracy
   p. Frequency, 0.5 percent accuracy
   q. Watt demand, 2 percent accuracy with programmable 5-, 10-, 15-, 30-minute intervals
   r. Watt-hours, 2 percent accuracy

6. Protection system of the following functions:

   s. Voltage phase loss, less than 50 percent nominal line voltage
   t. Current phase loss, less than 1/16 of the largest phase
   u. Voltage phase unbalance, 5 to 40 percent in 5 percent increments
   v. Phase voltage reversal
   w. Overvoltage, 105 to 140 percent in 5 percent increments
   x. Undervoltage, 95 to 60 percent in 5 percent increments
   y. Time delay for overvoltage, undervoltage, and phase unbalance, 0 to 8 seconds in 1-second intervals

7. Separate Form C (NO/NC) trip and alarm outputs contacts rated 10 amperes at 115-volt ac or 30-volt dc resistive.

8. Addressable communications card capable of transmitting all data to a central computer system via a two-wire network or through an RS-232C port.

O. Elapsed Time Meters: Provide nonreset type elapsed time meters to register up to 9999.9 hours, having square cases suitable for panel mounting and having coils for 120-volt, 60-hertz operation.

P. Control and Latching Relays: Provide control and latching relays of 600-volt class machine tool quality with convertible contacts. Provide relay operating contacts rated at a minimum of 10 amperes, 120 volts, 60 hertz.

Q. Timing Relays: Provide four-pole, double-throw, timing relays with timing ranges and ON/DELAY or OFF/DELAY operation as required. Provide contacts rated a minimum of 10 amperes at 120 volts, 60 hertz.

R. Reset and Repeat Cycle Timers: Provide electromechanical or solid-state type reset and repeat cycle timers, with timing ranges and functions as indicated. Provide contacts rated at a minimum of 10 amperes, 120 volts, 60 hertz. Solid-state output contacts are not acceptable.

S. Alternators: Provide alternators suitable for 120-volt, 60-hertz operation.

1. Provide alternator operating contacts rated at minimum of 5 amperes at 120 volts, 60 hertz.

2. Provide alternators suitable for circuit design requiring alternating "lead-lag" operations and concurrent "standby stage" operation.

T. Phase Failure and Undervoltage Relay: Furnish a 3-phase power monitor to detect phase failure, phase reversal, phase unbalance and undervoltage suitable for operation at 480 volts. Provide an adjustable drop out voltage range of 380 to 500 volts and an adjustable time delay from 0.2 to 20 seconds. Provide a normally open and normally closed alarm contact rated 10 amperes at 120 volts with automatic reset.

U. Ground Fault Protection Relay: Furnish a manually reset ground sensing relay suitable for use with a window type current transformer. Provide an adjustable time delay and pickup settings. Furnish single-pole, double-throw alarm contacts rated 10 amperes at 120 volts.

V. Control Power Transformer: Provide individual control power transformer for each starter to derive the 120 volts for the unit's control circuit. Provide transformers with sufficient capacity to meet the energy demands for all related control components including relays, solenoids and other indicated items. Provide dual fuses on the primary and one fuse on the secondary. Ground the unfused leg of the secondary to the enclosure.

W. Push Buttons, Selector Switches and Indicating Lights:

1. Provide heavy-duty, oiltight, push button or selector switch control stations arranged for flush panel mounting.
2. Provide additional switches, relays, and other electrical accessories to control and safeguard the operation of process equipment.

3. Provide 1-inch diameter, low voltage push-to-test type indicating lights with integral transformers for operation at 120-volt, 60-hertz ac control circuit voltages.

4. Color code indicating lights as follows:

Red - Motor running or valve open
Green - Motor off or valve closed
Amber - Capable of operation from this point
White - Alarm or trouble condition

X. Feeder Cable Terminals: Provide closed-end, compression-type solderless connectors and terminals, suitable for copper conductors for terminating cables in accordance with Section 16120.

Y. Wiring Schematic: Provide a schematic wiring diagram of each unit and affix it to the inside of the door of that unit.

Z. Identification: Provide nameplates in accordance with the requirements of Section 16195.

2.3 REMOTE CONTROL STATIONS

A. Remote Control Devices: Provide heavy-duty, oiltight remote control stations, consisting of push buttons, indicating lights, and selector switches with double-break silver contacts installed in NEMA 250 rated enclosures as follows:

NOTE: For NEMA 4X enclosures, fill in the locations required.

| AREA | ENCLOSURE |
|---|---|
| All areas listed Class 1, Division 1 or 2, Group D | NEMA 7 - Explosion-proof |
| | NEMA 4X - Corrosion-resistant fiberglass-reinforced thermal setting polyester formulation with stainless steel external hardware. Provide external operators of the same materials as that of the enclosure. |
| Outdoor and below grade elevation indoor | NEMA 4 - Watertight |
| Above grade indoor | NEMA 12 - Industrial |

B. Lockout Attachments:

1. Push Button Type: Use a pad lockable attachment that holds the button depressed.

2. Selector Switch: Use a pad lockable attachment that covers the selector switch operators and allows the switch to be set in any position. Selector switch operators that use a removable key are not acceptable.

C. Mount the remote control stations 4 feet 6 inches above finished floor to the centerline, unless otherwise shown. Mount all devices at least 1/2 inch away from concrete wall surfaces.

## 2.4 MANUAL MOTOR STARTERS

A. Manual Motor Starters: Provide toggle type thermal switch manual motor starters with neon pilot lights for all 120-volt, single-phase motors rated less than 1/2 hp.

1. Provide starters complete with HAND/OFF/AUTO selector switches, where required.

2. Provide starter enclosures as specified under the section Remote Control Stations.

3. Mount starters 4 feet 6 inches above the finished floor to centerline and 1/2 inch away from concrete wall surfaces, unless otherwise shown.

## 2.5 SOURCE QUALITY CONTROL

A. Tests: Shop test each motor control center in accordance with IEEE and NEMA standards.

1. Operational Tests: After the equipment has been completely assembled, perform operational tests to determine the general operating conditions and circuit continuity. Also, perform high potential tests and other standard tests for that particular class of equipment.

# PART 3 EXECUTION

## 3.1 INSTALLATION

A. General: Install all equipment in accordance with the manufacturer's recommendations and approved shop drawings and as specified in Division 1.

B. Adjustments: Set all motor circuit protectors and circuit breakers for the approved short circuit and coordination study.

C. Overloads: Adjust the thermal overloads on each phase of the starter units to the actual motor installed.

D. Cable Connections: Terminate and label all field wiring per the approved diagrams.

E. Torque Requirements: Tighten electrical connectors and terminals, including screws and bolts, in accordance with equipment manufacturers' published torque tightening recommendations. Where manufacturers' torquing requirements are not available, tighten connectors and terminals in accordance with UL Standard 486 A.

## 3.2 FIELD QUALITY CONTROL

A. Inspections: Inspect, adjust and check the installation for physical alignment, cable terminations and ventilation.

B. Tests: Perform the following field tests:

1. Close and open each circuit breaker and motor circuit protector to test operation.

2. Energize the motor control center and test for hot spots.

3. When site conditions permit, energize and de-energize each equipment item served by each motor control center, testing the complete control sequence of each item.

## 3.3 OPERATION DEMONSTRATION

NOTE: Confirm that requirements are detailed in Division 1.

A. Manufacturers Service Representative: Provide the services of a qualified factory-trained Service Engineer, as specified in Division 1.

8.y Provide Service Engineer when the equipment is placed into operation.

9.y Provide Service Engineer at job site as often as necessary until all problems are corrected and the equipment installation and operation are satisfactory.

NOTE: Confirm that requirements are detailed in Division 1.

B. Operation and Maintenance: Provide operation and maintenance instructions as specified in Division 1.

## 3.4 CLEANING AND PAINTING

A. Shop Painting: Paint motor control centers in accordance with Section 09900.

B. Field Painting: Furnish three 12-ounce spray cans of the final finish. Clean and touch up any scratched or marred surface to match original finish.

END OF SECTION

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