UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
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DIVISION 26 - ELECTRICAL

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10/07

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-- End of Section Table of Contents --

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USACE / NAVFAC / AFCEC / NASA **UFGS-26 28 00.00 10 (October 2007)**

Preparing Activity: USACE **Superseding**
UFGS-26 28 00.00 10 (April 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
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SECTION 26 28 00.00 10

MOTOR CONTROL CENTERS, SWITCHBOARDS AND PANELBOARDS
10/07

****
NOTE: This guide specification covers the requirements for motor control centers, switchboards and panelboards by formal advertising, using a SUPPLY-type contract. This section was originally developed for USACE Civil Works projects.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
****

PART 1 GENERAL

****
NOTE: This section includes the technical requirements for the types of equipment provided at navigation locks and dams, flood control pumping plants, and hydroelectric power plants to supply auxiliary power to the power plant, switchyard, dam and other project facilities.

Applicable portions of this document will be incorporated into electrical specifications when equipment is purchased using a CONSTRUCTION-type contract. Modifications needed to do this will include: Modifying submittal requirements to eliminate submittals tied to notice to proceed

dates, adding a PART 3 EXECUTION section covering installation of the equipment, adding installation material, such as conduit and wire, and quality information to PART 2 PRODUCTS. Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM may be used as a basis for the EXECUTION section.

Suitable drawings showing the general arrangement and single-line diagram of each motor control center, switchboard, and panelboard should be included with the procurement specifications. The drawings should show the locations of conduit and cable entrances, details of nameplates, and tabulations showing the NEMA size of contactors and motor controllers, trip ratings of circuit breakers, solid state trips where required, alarm and bell contacts and shunt trips where required, sizes of feeder and branch circuit conductors, and ratings of motors and other loads.

This specification covers NEMA Class II motor control centers where interlocking and remote control are required as is engineering effort on the part of the manufacturer. Where cost savings may be realized by grouping motor controls together, but where motor operations are not interlocked, locally or remotely, and no manufacturer's engineering effort required, NEMA Class I should be used. This specification may be modified for NEMA Class I motor control centers by deleting the following paragraphs from PART 2:

WIRING (except when applicable to switchboards)

TERMINAL BLOCKS (except when applicable to switchboards)

MOTOR CONTROL CENTERS - change references to Class II, type B and C.

Horizontal Wireways - the option for mater terminal block compartment should generally not be included.

Wiring for Motor Control Centers

Alternators

Operational Tests

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1.1 SUMMARY

****

NOTE: Drafts of specifications submitted to higher authority for review and approval will consist of printed copies of this guide specification combined with pertinent sections of procurement documents as call for on Standard Form 33, both revised as required for the particular procurement.

Instructions for the preparation and submission of specifications for approval are included in ER 1110-2-1200.

The following is a bid item list to be included in section B of Standard Form 33 of a supply contract. This example should be modified to fit the individual contract requirements. Dissimilar motor control centers, switchboards and panelboards should be entered as separate bid items.

SECTION B SUPPLIES/SERVICES AND PRICES					
ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	U/M	UNIT PRICE	AMOUNT
0001	480-VOLT, 3-PHASE, UNIT MOTOR CONTROL CENTER (NO. _____)	1	JOB	EACH	[_____]
000X	480-VOLT, 3-PHASE, MOTOR CONTROL CENTER (NO. _____)	1	JOB	EACH	[_____]
000X	480-VOLT, 3-PHASE, POWER DISTRIBUTION PANELBOARD (NO. _____)	1	JOB	EACH	[_____]
000X	480-VOLT, 3-PHASE, POWER DISTRIBUTION PANELBOARD (NO. _____)	1	JOB	EACH	[_____]
000X	ACCESSORIES AND SPARE PARTS	1	LOT	XXXX	[_____]
000X	CONTRACT DATA (PART 1, THE SCHEDULE) (SEE DD FORM 1423, EXHIBIT B)			Not separately priced	
				TOTAL	[_____]

****

These specifications include the design, fabrication, assembly, wiring, testing, and delivery of the items of equipment and accessories and spare parts listed in the Schedule and shown on the drawings.

1.2 REFERENCES

****

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically

be deleted from this section of the project specification when you choose to reconcile references in the publish print process.
****

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	((2014; Errata 2016) Electric Meters - Code for Electricity Metering

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1	(2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B1.20.2M	(2006; R 2011) Pipe Threads, 60 Deg. General Purpose (Metric)

ASTM INTERNATIONAL (ASTM)

ASTM B187/B187M	(2020) Standard Specification for Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar and Shapes
ASTM B317/B317M	(2007; R 2015; E 2016) Standard Specification for Aluminum-Alloy Extruded Bar, Rod, Tube, Pipe, Structural Profiles, and Profiles for Electrical Purposes (Bus Conductor)

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C57.13	(2016) Requirements for Instrument Transformers

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C12.4	(1984; R 2011) Registers - Mechanical Demand
NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 4	(2015) Application Guideline for Terminal Blocks
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures

NEMA PB 1	(2011) Panelboards
NEMA PB 2	(2011) Deadfront Distribution Switchboards
NEMA ST 1	(1988; R 1994; R 1997) Specialty Transformers (Except General Purpose Type)
NEMA ST 20	(2014) Dry-Type Transformers for General Applications
NEMA/ANSI C12.10	(2011) Physical Aspects of Watthour Meters - Safety Standards
NEMA/ANSI C12.11	(2006; R 2019) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 44	(2018) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 67	(2018; Reprint Jul 2020) UL Standard for Safety Panelboards
UL 489	(2016) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 845	(2005; Reprint Oct 2018) UL Standard for Safety Motor Control Centers
UL 891	(2005; Reprint Oct 2012) Switchboards
UL 1063	(2017) UL Standard for Safety Machine-Tool Wires and Cables

1.3 SUBMITTALS

****

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other

submittal items can be reviewed by the Contractor's Quality Control System. Only add a “G” to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

****

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Drawings; G[, [_____]]
Shop Drawings; G[, [_____]]
Motor Control Centers; G[, [_____]]
Switchboards; G[, [_____]]
Panelboards; G[, [_____]]

SD-03 Product Data

Equipment; G[, [_____]]
Factory Tests

SD-06 Test Reports

Factory Tests

SD-07 Certificates

Motor Control Centers

1.4 DELIVERY, STORAGE, AND HANDLING

****

NOTE: ABC phasing should be in accordance with NFPA 70 front-to-back, top-to-bottom, and left-to-right. Alternate phasing should be avoided, but where this cannot be done, the drawings should clearly reflect alternate phasing, and these specifications be modified to include requirement for marking the equipment.

****

Submit [6] [_____] copies of such descriptive cuts and information as are required to demonstrate fully that all parts of the equipment will conform to the requirements and intent of the specifications, within [30] [_____] calendar days after [date of award] [date of receipt of notice to proceed] for approval. Data shall include descriptive data showing typical construction of the types of equipment proposed, including the manufacturer's name, type of molded case circuit breakers or motor circuit protectors, performance capacities and other information pertaining to the equipment. [Also [6] [_____] sets of characteristic curves of the individual breaker trip element.] Ship the equipment as completely assembled and wired as feasible so as to require a minimum of installation work. Each shipping section shall be properly match marked to facilitate reassembly, and shall be provided with removable lifting channels with eye bolts for attachment of crane slings to facilitate lifting and handling. Any relay or other device which cannot withstand the hazards of shipment when mounted in place on the equipment shall be carefully packed and shipped separately. These devices shall be marked with the number of the panel which they are to be mounted on and fully identified. All finished painted surfaces and metal work shall be wrapped suitably or otherwise protected from damage during shipment. All parts shall be prepared for shipment so that slings for handling may be attached readily while the parts are in a railway car or transport truck. [Sections of equipment crated for shipment shall be of such size, including crates, that they will pass through a [_____] by [_____] -meter -foot hatch opening and a [_____] by [_____] -meter -foot wall opening.] All spare parts and accessories shall be carefully packaged and clearly marked.

1.5 MAINTENANCE

1.5.1 Accessories and Tools

Furnish a complete set of accessories and special tools unique to equipment provided and required for erecting, handling, dismantling, testing and maintaining the apparatus.

1.5.2 Extra Materials

****

NOTE: If three or more motors of the same size and manufacturer are required, the designer should specify more spare heater elements.

****

Furnish spare parts as specified below. All spare parts shall be of the same material and workmanship, shall meet the same requirements, and shall be interchangeable with the corresponding original parts furnished.

SPARE PARTS	
Amount	Description
2 of each type and size	Fuses
1	Circuit breaker auxiliary switch
2 for each size ac contactor	Operating coils
1 for each size dc contactor	Operating coil
2 Complete sets for each size ac contactor	3-pole stationary and moving contact assemblies
1 Complete set for each size dc contactor	2-pole stationary and moving contact assemblies
3 of each type and rating	Contactor overload relays, each relay with a complete set of contact blocks
1 Spare set for each heater rating provided	Heater elements
2 for each type	Indicating lamp assemblies
1 of each type and rating	Control transformer
1 of each type and rating	Control relay
1 of each type	Contactor auxiliary contact
4 One quart containers	Finish paint for indoor equipment
2 One quart containers	Paint used for the exterior surfaces of outdoor equipment
4	Keys for motor control center door loc

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Provide materials and equipment which are standard products of a manufacturer regularly engaged in their manufacture and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening and that conform to the requirements of these specifications. Materials shall be of high quality, free from defects and imperfections, of recent manufacture, and of the classification and grades designated. All materials, supplies, and articles not manufactured by the Contractor shall be the products of other recognized reputable manufacturers.

2.1.1 Rules

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NOTE: Many manufacturers represent IEC ratings as equivalent to NEMA ratings or UL labeling. The two are different standards philosophies and are not interchangeable. IEC ratings are not acceptable

under this specification. For further information, see NEMA ICS 2.4, "NEMA AND IEC DEVICES FOR MOTOR SERVICE - A GUIDE FOR UNDERSTANDING THE DIFFERENCE."
****

Provide equipment conforming to the requirements of NFPA 70 unless more stringent requirements are indicated herein or shown. NEMA rated and UL listed equipment has been specified when available. Equipment shall meet NEMA and UL construction and rating requirements as specified. No equivalent will be acceptable. Immediately notify the Contracting Officer of any requirements of the specifications or Contractor proposed materials or assemblies that do not comply with UL or NEMA. International Electrotechnical Commission (IEC) rated equipment will not be considered an acceptable alternative to specified NEMA ratings.

2.1.2 Coordination

****
NOTE: Combination motor controllers, using motor circuit protectors (MCP's) instead of thermal-magnetic circuit breakers, are offered as standard by several major manufacturers; however, the thermal-magnetic type is still offered as an option. The MCP is designed especially for motor circuits and will generally provide better protection for motors, controllers, and circuit conductors than the thermal-magnetic type. In any case, one or the other should be specified, so that all bids will be on the same basis. Generally, thermal magnetic breakers should be specified for reduced voltage starters because MCP do not have high enough current settings to avoid nuisance tripping from current inrush and switching transients generated during start to run sequence.

This specification does not cover the use of fused motor protection. Fuses are the least cost alternative, but require more maintenance. They are not recommended for powerhouse applications. Fuses may be acceptable for other applications, provided that suitable phase-voltage-unbalance protection for motors is specified.

When PART 3 criteria are added for CONSTRUCTION contracts, take care to prevent conflicts, gaps, or omissions.
****

The general arrangement of the motor control centers, switchboards and panelboards is shown on the contract drawings. Any modifications of the equipment arrangement or device requirements as indicated will be subject to the approval of the Contracting Officer. If any conflicts occur necessitating departures from the drawings, details of and reasons for departures shall be submitted and approved prior to implementing any change. Completely assemble all equipment at the factory. The motor control centers and switchboards may be disassembled into sections, if necessary, for convenience of handling, shipping, and installation.

2.2 NAMEPLATES

Provide nameplates made of laminated sheet plastic or of anodized aluminum approximately 4 mm 1/8 inch thick, engraved to provide white letters on a black background. The nameplates shall be fastened to the panels in proper positions with anodized round-head screws. Lettering shall be minimum 13 mm 1/2 inch high. Nameplate designations shall be in accordance with lists on the drawings, and as a minimum shall be provided for the following equipment:

a. Motor Control Centers

b. Individual items of equipment mounted in the Motor Control Centers

c. Switchboards

[d. Individually-mounted circuit breakers in Switchboard]

[e. Group-mounted circuit breakers in Switchboard]

f. Panelboards

[g. Individually-mounted circuit breakers in Panelboard]

Provide equipment of the withdrawal type with nameplates mounted on the removable equipment in locations visible when the equipment is in place.

2.3 CONNECTIONS

All bolts, studs, machine screws, nuts, and tapped holes shall be in accordance with ASME B1.1. The sizes and threads of all conduit and fittings, tubing and fittings, and connecting equipment shall be in accordance with ASME B1.20.2MASME B1.20.1. All ferrous fasteners shall have rust-resistant finish and all bolts and screws shall be equipped with approved locking devices. Manufacturer's standard threads and construction may be used on small items which, in the opinion of the Contracting Officer, are integrally replaceable, except that threads for external connections to these items shall meet the above requirements.

2.4 MOLDED CASE CIRCUIT BREAKERS

Molded case circuit breakers shall conform to the applicable requirements of UL 489 and UL 489. The circuit breakers shall be manually-operated, shall be quick-make, quick-break, common trip type, and shall be of automatic-trip type unless otherwise specified or indicated on the drawings. All poles of each breaker shall be operated simultaneously by means of a common handle. The operating handles shall clearly indicate whether the breakers are in "On," "Off," or "Tripped" position and shall have provisions for padlocking in the "Off" position. Personnel safety line terminal shields shall be provided for each breaker. The circuit breakers shall be products of only one manufacturer, and shall be interchangeable when of the same frame size. [Where indicated on the drawings, circuit breakers shall be provided with shunt trip devices.] [Where indicated on the drawings, circuit breakers shall be provided with bell alarm contacts that close on automatic operation only. The contacts shall be suitable for [125] [_____] volts dc and shall reset when the breaker is reset.]

2.4.1 Trip Units

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NOTE: Both thermal magnetic and solid state trip units have been included in this specification. Solid state units can be more reliable and permit more selective coordination since they can have long time pick-up, long time delay, short time pick-up, short time delay, instantaneous pick-up, ground fault pick-up, and ground fault time delay settings. Solid state units have come down in price and are becoming competitive with thermal magnetic units. Specific locations where solid state trips are required should be indicated on the drawings.

****

Except as otherwise noted, the circuit breakers, of frame sizes and the trip unit ratings as shown on the drawings, shall be provided with combination thermal and instantaneous magnetic or solid state trip units. The Government reserves the right to change the indicated trip ratings, within frame limits, of the trip devices at the time the shop drawings are submitted for approval. Submit [6] [_____] copies of outline drawings of all equipment to be furnished under this contract, together with weights and overall dimensions, within [30] [_____] calendar days after [date of award] [date of receipt of notice to proceed], for the approval of the Contracting Officer. The breaker trip units shall be interchangeable and the instantaneous magnetic trip units shall be adjustable on frame sizes larger than 150 amperes. Nonadjustable instantaneous magnetic trip units shall be set at approximately 10 times the continuous current ratings of the circuit breakers. [Solid state trip units, where indicated, shall also have adjustable [long time pick-up and delay],[short time pick-up and delay], [and ground fault pick-up and delay].]

2.4.2 480-Volt AC Circuits

Circuit breakers for 480-volt or 277/480-volt ac circuits shall be rated 600 volts ac, and shall have an UL listed minimum interrupting capacity of [14,000] [_____] symmetrical amperes at 600 volts ac.

2.4.3 120/240-Volt AC Circuits

Circuit breakers for 120-volt ac circuits shall be rated not less than 120/240 or 240 volts ac, and shall have a UL listed minimum interrupting capacity of [10,000] [_____] symmetrical amperes.

2.4.4 125-Volt DC Circuits

Circuit breakers for 125-volt dc circuits shall be two-pole rated 125/250 or 250 volts dc, and shall have an UL listed minimum interrupting capacity of [5,000] [10,000] [_____] amperes dc.

2.5 WIRING

All control wire shall be stranded tinned copper switchboard wire with 600-volt flame-retardant insulation Type SIS meeting UL 44 or Type MTW meeting UL 1063, and shall pass the VW-1 flame tests included in those standards. Hinge wire shall have Class K stranding. Current transformer secondary leads shall be not smaller than No. 10 AWG. The minimum size of control wire shall be No. 14 AWG. Power wiring for 480-volt circuits and

below shall be of the same type as control wiring and the minimum size shall be No. 12 AWG. Special attention shall be given to wiring and terminal arrangement on the terminal blocks to permit the individual conductors of each external cable to be terminated on adjacent terminal points.

2.6 TERMINAL BLOCKS

Control circuit terminal blocks for control wiring shall be molded or fabricated type with barriers, rated not less than 600 volts. The terminals shall be removable binding, fillister or washer head screw type, or of the stud type with contact and locking nuts. The terminals shall be not less than No. 10 in size and shall have sufficient length and space for connecting at least two indented terminals for 10 AWG conductors to each terminal. The terminal arrangement shall be subject to the approval of the Contracting Officer and not less than four (4) spare terminals or 10 percent, whichever is greater, shall be provided on each block or group of blocks. Modular, pull apart, terminal blocks will be acceptable provided they are of the channel or rail-mounted type. Submit data showing that the proposed alternate will accommodate the specified number of wires, are of adequate current-carrying capacity, and are constructed to assure positive contact between current-carrying parts.

2.6.1 Types of Terminal Blocks

2.6.1.1 Short-Circuiting Type

Short-circuiting type terminal blocks shall be furnished for all current transformer secondary leads and shall have provision for shorting together all leads from each current transformer without first opening any circuit. Terminal blocks shall meet the requirements of paragraph CONTROL CIRCUIT TERMINAL BLOCKS above.

2.6.1.2 Load Type

Load terminal blocks rated not less than 600 volts and of adequate capacity shall be provided for the conductors for NEMA Size 3 and smaller motor controllers and for other power circuits except those for feeder tap units. The terminals shall be of either the stud type with contact nuts and locking nuts or of the removable screw type, having length and space for at least two indented terminals of the size required on the conductors to be terminated. For conductors rated more than 50 amperes, screws shall have hexagonal heads. Conducting parts between connected terminals shall have adequate contact surface and cross-section to operate without overheating. Each connected terminal shall have the circuit designation or wire number placed on or near the terminal in permanent contrasting color.

2.6.2 Marking Strips

White or other light-colored plastic marking strips, fastened by screws to each terminal block, shall be provided for wire designations. The wire numbers shall be made with permanent ink. The marking strips shall be reversible to permit marking both sides, or two marking strips shall be furnished with each block. Marking strips shall accommodate the two sets of wire numbers. Each device to which a connection is made shall be assigned a device designation in accordance with NEMA ICS 1 and each device terminal to which a connection is made shall be marked with a distinct terminal marking corresponding to the wire designation used on

the Contractor's schematic and connection diagrams. The wire (terminal point) designations used on the Contractor's wiring diagrams and printed on terminal block marking strips may be according to the Contractor's standard practice; however, additional wire and cable designations for identification of remote (external) circuits shall be provided for the Government's wire designations. Drawings shall show the general arrangement and overall dimensions of the motor control centers, switchboards, and panelboards. These drawings shall show space requirements, details of any floor supports to be embedded in concrete and provisions for conduits for external cables. Prints of drawings submitted for approval will be so marked and returned to the Contractor for addition of the designations to the terminal strips and tracings, along with any rearrangement of points required.

2.7 SPACE HEATERS

****

NOTE: Heaters should be connected to an external power source in installations where the motor control center will not be energized continuously.

****

Space heaters shall be provided where indicated on the drawings and shall be controlled using an adjustable 10 to 35 degrees C 50 to 90 degrees F thermostat, magnetic contactor, and a molded-case circuit breaker [and a 480-120 volt single-phase transformer]. The space heaters shall be 250-watt, 240 volt strip elements operated at 120 volts and shall be [supplied from the motor control center bus] [wired to terminal blocks for connection to 120-volt single-phase power sources located external to the control centers]. The contactors shall be open type, electrically-held, rated 30 amperes, 2-pole, with 120-volt ac coils.

2.8 MOTOR CONTROL CENTERS

****

NOTES: This specification covers single stand alone lineup with front access. Not all arrangements can be listed and labeled under UL 845. Consult manufacturer's literature and UL listing availability for specific arrangements.

Auxiliary motor control centers should be NEMA Class II, Type B or C, as applicable. Type C construction includes master section terminal boards at the top or bottom of each vertical section and complete control wiring and power wiring for NEMA Size 3 and smaller controllers between the unit assemblies in each section and the master terminal boards. Type C construction is preferred and should be specified whenever a considerable amounts of interpanel control wiring or external control circuits is required. Designer should consider number of terminal blocks required for type C construction and ensure that there is sufficient space and access.

Where the unit assemblies consist primarily of feeder tap units with circuit breakers to supply power loads or starter units for individually controlled motors (such as for pumps in pumping

stations), and very little interpanel and external control wiring is required, the less expensive Type B construction, which does not include master section terminal boards, should be specified. If the procurement includes both types of control centers, the type of each control center should be clearly indicated.

The intent of the submittals below is to require NEMA Class II drawing packages. When it is desirable for the Government's wire numbers to be included on the drawings or custom drawing sizes and title blocks are required, NEMA Class IIS should be specified.

Should this specification be used in procurement of NEMA Class I equipment, the drawing packages are less involved and this paragraph edited accordingly.

Include this requirement only when contractual certification is required and Factory Test Reports without certification are not acceptable.

****

Each motor control center shall be designed for operation on 480-volts ac, 3-phase, 60-Hz system, and the equipment shall conform to all the applicable requirements of NEMA ICS 1, NEMA ICS 2, NEMA ICS 4and NEMA ICS 6. Vertical sections and individual units shall be listed and labeled under UL 845 where ever possible. In lieu of the UL listing, certification from any nationally recognized, adequately equipped, testing agency that the individual units and vertical sections have been tested and conform to the UL requirements of that agency will be acceptable when approved by the Contracting Officer.

a. Certification of factory test reports. Certification shall be signed by official authorized to certify on behalf of the manufacturer, attesting that the motor control center meets the specified requirements. The statement shall be dated after the award of this contract, shall state the Contractor's name and address, shall name the project and location, and shall list the specific requirements which are being certified.

b. The motor control center shall be NEMA Class II, [Type B] [Type C] [Type B or C as indicated in the bid item list], motor control centers in accordance with NEMA ICS 2. Submit [6] [_____] copies of electrical equipment drawings, within [30] [_____] calendar days after [date of award] [date of receipt of notice to proceed], for the approval of the Contracting Officer. [The NEMA Class II[S] motor control center drawings shall include a connection diagram with wire designations and schematic diagrams to illustrate operation of associated motor unit controls.]

c. Submit an individual wiring diagram for each motor control center. [Wiring diagrams shall be in a form showing physical arrangement of the control center with interconnecting wiring shown by lines or by terminal designations (wireless).] Provide a single-line diagram, equipment list and nameplate schedule for each switchboard and panelboard.

2.8.1 Enclosures

****

NOTES: Stand alone front access line-ups are most desirable for ease of operation and maintenance, but particular installations may require specialized arrangements, such as back-to-back mounted units. Consult manufacturers for specialized requirements.

NFPA 70 Article 430H lists the various NEMA enclosure types for Motor Control Centers. Designer should ensure that the NEMA type specified meets design requirements.

****

Each motor control center shall consist of the required number of vertical sections of 2250 mm 90 inches nominal height, bolted together, with steel channel sills and suitable for mounting against a wall. Vertical section shall be 510 mm 20 inches deep and buses, control wiring, control transformers, small power transformers, terminal blocks, line terminals, cable supports, and clamps shall be accessible from the front. Enclosure shall be NEMA Type [1 gasketed] [12] [3R]. The control centers shall be fabricated from smooth select steel sheets shaped and reinforced to form rigid free-standing structures. Metal thickness for enclosures shall be not less than specified in NEMA ICS 6 without exception. Vertical edges of sections exposed to view shall be so fabricated and bolted that the joints will not pass a 1.6 mm 1/16 inch gage. Each structure shall be designed for addition of future sections required. Individual compartments shall be isolated from adjacent compartments.

2.8.1.1 Unit Compartments

Each operating unit shall contain equipment as shown on the drawings, mounted in an individual cell. The unit assembly, except main circuit breakers, panelboards and auxiliary control devices, shall be drawout type removed from the front, without rear access or disturbing other units in the control center assembly. All drawout type unit assemblies shall have positive guide rail system to ensure alignment of connection to vertical bus. Units shall be mechanically interlocked with the door to prevent removal while in the energized position. Each removable unit shall have provision for padlocking in a position in which it is disconnected from the vertical bus although not removed from the stationary structure. All ventilating openings shall be provided with corrosion-resistant insect-proof screens on the inside. Bus closing plugs shall be provided for all unused openings in vertical bus barriers.

2.8.1.2 Motor Control Center Doors and Covers

Each unit compartment, including blank compartments for future use, shall be provided with either a flange-formed or a rolled-edge door. Each door shall be mounted on fully-concealed or continuous full-length piano-type hinges and shall be provided with positive fasteners. Door sag shall be prevented by proper alignment of hinges made of sufficiently strong material. The door fastenings shall be so interlocked to prevent opening when the equipment is energized. The external operating handle shall clearly indicate whether the equipment is in an "ON", "OFF" or "TRIPPED" position.

2.8.1.3 Horizontal Wireways

[Structure shall have a minimum 300 mm 12 inches high wireway at the top and a 150 mm 6 inches minimum wireway at the bottom.] [Structure shall have a minimum 150 mm 6 inches high wireway at the top and a 300 mm 12 inches minimum wireway at the bottom.] Both horizontal wireways shall run the length of the structure [A master terminal block compartment with full length wireway space shall be provided at the [top] [bottom] [where indicated] in all Type C assemblies.] Cover plates shall be provided on the side of the assembly to permit extension of the horizontal bus and wireway when vertical sections are added.

2.8.1.4 Vertical Wireways

Vertical wireways shall be provided in all vertical sections accepting multiple plug-in components. Vertical wireways shall connect with horizontal wireways at the top and bottom and be a minimum 100 mm 4 inches wide. Barriers shall be provided in sections containing both ac and dc vertical buses. Doors shall be provided on each vertical wireway. The exposed surface of any door shall not deviate more than 1.5 mm 1/16 inch from a true plane.

2.8.1.5 Sills

****

NOTE: Structural sills are options provided by most manufacturers and provide the structural stability desired for equipment subject to the vibration of a powerhouse. When equipment is to be mounted on sills and on a maintenance pad, the 78" NFPA 70 requirement for height to operating handle may be exceeded unless space for operator to stand on pad is provided.

****

Channel iron foundations, complete with bolts and drilled holes for grouting and anchoring to the floor, shall be furnished for the complete length (front and rear) of each motor control center assembly. The channels shall be designed for flat mounting and maximum channel depth shall be 38 mm 1-1/2 inches. Additional channel or substantial metal trim shall be provided flush with the end panels to completely enclose the bases across the ends of the equipment assemblies.

2.8.1.6 NEMA 3R Enclosures

****

NOTE: Enclosures covered by this specification are not intended to be non walk-in type. Walk-in front-aisle, walk-in common aisle and walk through common aisle styles are available, and where required should be specified. The latter styles of enclosures shall comply with NFPA 101 for means of egress and lighting.

****

The motor control center shall be non-walk in NEMA Type 3R rainproof enclosure as shown on the drawings. The outside enclosure shall consist of smooth select steel sheets on a structural steel frame. Full-length single or double doors shall be provided with top and bottom bolts and a

center latch operated by means of a keyed handle. Steel sheets and doors shall be not less than 3.5 mm No. 10 gage thick and doors shall have bent angle or channel edges with all corner seams welded and ground smooth. The motor control center within the enclosure shall be assembled with adequate gaskets and structure to assure a measure of vandal resistance. Ventilating openings and an effective insulating air space of approximately 50 mm 2 inches shall be provided below the roof of the structure which shall slope from front to back for adequate drainage. The outside edges of the control center base shall permit easy sealing at the concrete surface with mastic compound. A 200-watt outdoor lighting fixture with globe and guard shall be furnished to light the front of the assembly. All lighting connections shall be watertight. A weatherproof switch installation shall be furnished on the front or side of the enclosure so that the light can be switched prior to opening the assembly doors. The exterior manual switch shall be "ac" rated, 15 amperes, 120/277 volts. Two duplex receptacle units shall be provided within the outer weatherproof enclosure. The lighting fixture and receptacles shall be wired to the 120-volt ac panelboard located in the control center, and external wiring shall be run in rigid galvanized steel conduit.

2.8.1.7 Shutters

Drawout units shall have shutters which close when the unit is withdrawn to isolate the vertical bus.

2.8.1.8 [Thermostatically Controlled Strip Heaters

****
NOTE: Delete this paragraph when not required.
****

Thermostatically controlled strip heaters as specified in paragraph SPACE HEATERS shall be provided [in all motor control centers] [where indicated].]

2.8.2 Buses

****
NOTES: When either copper of aluminum bus are allowed the manufacturers will generally provide the less expensive aluminum. Use ASTM 317 when aluminum bus is permitted.

NEMA ICS 2 allows a 65 degrees C 117 degrees F temperature rise on the buses, irrespective of the equipment used. UL 845 allows 65 degrees C 117 degrees F temperature rise only under certain conditions. In general this means all buses must be plated and devices must be UL labeled for the higher temperatures. If this is not the case, the UL standard for temperature rise is 50 degrees C 90 degrees F creating a conflict with NEMA. The designer should be aware of this difference. This specification references the UL standard and bases the rise on the exceptions it permits.
****

All buses shall be of copper [or aluminum] and [all bolted splices and connections between buses and for extensions or taps for equipment shall

be tin or silver-plated] [shall be tin or silver-plated throughout]. Copper [or aluminum] bars and shapes for bus conductors shall conform to the applicable requirements of ASTM B187/B187M [, and ASTM B317/B317M]. All splices for field assembly shall be bolted with at least two bolts and shall employ the use of "Belleville" washers in the connection. The bus ratings shall be based on a 65 degree Celsius maximum temperature rise in accordance with UL 845 requirements. Bus shall have a short-circuit current rating of not less than [42,000] [65,000] [100,000] RMS symmetrical amperes. All bus work shall be supported on wet process porcelain insulators, glass polyester, or suitable molded material.

2.8.2.1 Horizontal Bus

Each control center assembly shall be provided with a three-phase main horizontal bus, with a continuous current rating not less than [600] [800] [1,000] [1,200] amperes, located across the top of each vertical section. The ends of horizontal buses shall be drilled for future extensions. [The main horizontal bus shall be fully insulated.]

2.8.2.2 Vertical Bus

Each vertical section shall be provided with a three-phase vertical bus with a continuous current rating of [300] [600] amperes connected to the horizontal bus by brazing, welding, or bolting. Where the incoming feeder breakers are located at the bottom of a control center, the vertical bus in that section shall be rated the same as the main horizontal bus. Vertical buses shall extend from the horizontal bus to the bottom of the lowest available unit mounting space. The vertical bus shall be isolated from wireways and equipment in compartments.

2.8.2.3 [Ground Bus

****
NOTE: Delete this paragraph when not required.
****

A copper [or aluminum] ground bus shall be provided full width at the bottom of the motor control center line-up. A full clamp-type solderless copper or copper alloy lug for No. 2/0 AWG stranded copper cable shall be provided at each end of the bus for connection to the station grounding system.]

2.8.2.4 [Neutral Bus

****
NOTE: Delete this paragraph when not required.
****

A [half] [fully] rated neutral bus shall be furnished continuous through the control center. Lugs of appropriate capacity will be furnished.]

2.8.3 Combination Starters

****
NOTES: The minimum bus short-circuit rating for most manufacturers is 42,000 amps rms symmetrical. Most combination starters without current limiting type circuit breakers or motor circuit protectors have a short circuit rating of 25,000 amps. The

designer shall evaluate the available short circuit current for a particular installation and place that value in the space provided.

When short-circuit ratings above 25,000 amps are required, the designer should consult manufacturer's data for the availability of non-current limiting devices at the specific rating and where needed, show current limiting circuit breakers or motor circuit protectors the drawings.

In accordance with NEMA ICS 2, the motor control center short-circuit rating is the maximum available rms symmetrical current in amperes permissible at its line terminals which are computed as the sum of the maximum available current of the system at the point of connection and the short-circuit current contribution of the motors connected to the control center. In the absence of more precise information, the motor short-circuit current contribution may be assumed to equal four times the continuous current rating of the motor control center.

Reduced voltage type starters are specified in the following paragraph. They should be used in specialized applications, and indicated on the drawings. Reduced voltage starting should be avoided where possible.

This specification does not cover reversing starters. Where a reversing starter is required, indicate reversing and non-reversing starters on the drawings, and modify the specification for clarity.

NEMA sizes are based on continuous duty motors. Where acceleration time exceeds 10 seconds, or plugging or jogging duty are required, consult the manufacturer.

For high efficiency motors, the designer shall investigate time-current curve characteristics of the circuit breaker or MCP overcurrent protection to ensure that the increased starting current of these motors does not exceed the NFPA 70 standard ratings.

To determine whether to select motor circuit protectors or molded-case circuit breakers, see subparagraph Coordination in Part 1.

****

Combination motor controller units shall contain [motor circuit protectors] [molded-case circuit breakers], auxiliary and pilot devices and [a magnetic contactor with thermal overload relays] [[or] [and] reduced voltage starter where indicated on the drawings]. The ratings of [motor circuit protectors,] air circuit breakers, contactors, motor controllers and other devices shall be as shown on the drawings. All combination motor controller units shall have short circuit ratings equal to [_____] or greater. Where control push-buttons, indicating lamps, "Hand-Off-Automatic" switches, and similar control devices are associated

with a unit, they shall be mounted on the unit compartment door. Door-mounted components shall not interfere with access within the compartments. [Molded case circuit breakers for use in combination starters shall meet the requirements of paragraph MOLDED CASE CIRCUIT BREAKERS.] [Motor circuit protectors shall be only part of the combination starters as required by NFPA 70 and shall conform to all requirements of paragraph MOLDED CASE CIRCUIT BREAKERS, except that trip units shall have provision for locking the selected trip setting.]

2.8.3.1 Magnetic Contactors

Magnetic contactors shall be of the NEMA sizes indicated on the drawings. The rating, performance and service characteristics shall conform to the requirements of NEMA ICS 2 for contactors with continuous current ratings for the duty indicated. Contactors for motor control shall be rated for full-voltage starting (Class A controllers). Contactors shall be suitable for at least 200,000 complete operations under rated load without more than routine maintenance. The interruption arc and flame shall be minimized by suitable arc chutes or other means so that no damage will be done to other portions of the device. The arc chutes, if provided, shall be easily removable without removing or dismantling other parts. The contacts shall be easily removable. All current-carrying contact surfaces shall be silver-surfaced or of other approved material to prevent the formation of high resistance oxides. The contactor shall operate without chatter or perceptible hum while energized. Coils shall be suitable for continuous operation [120-volt ac] [480-volt ac] [125-volt dc] circuits. Alternating-current contactors shall be three-pole, except where otherwise noted, and shall be insulated for 600 volts ac and of the electrically-operated, magnetically-held type. Direct-current contactors shall be two-pole, suitable for controlling circuits operating at 125 volts dc, insulated for 250 volts dc, electrically-operated, magnetically-held type and adequate for full-voltage motor starting service.

2.8.3.2 [Reduced Voltage Starters

****

NOTES: Motor loads using reduced voltage starting must be able to operate with reduced starting torque.

Autotransformer starters should be used when voltage drop due to motor starting current is a problem. Solid state starters may also be used. Designer to determine best alternative.

Solid state starters provide a smooth acceleration and are suitable for pump starting. Acceleration requirements must be coordinated to specific motor.

Delete this paragraph when reduced voltage starters are not required.

****

[Autotransformers shall be rated for medium duty and have taps according to NEMA ICS 2. For thermal over load protection, the autotransformer shall have normally closed thermostat wired in series with the normally closed thermal overload contact of the starter. Initial connection shall be to the [65] [_____] percent tap.] [Solid State soft-start starters shall be three phase SCR controlled for stepless reduced voltage starting of induction motors.] Current transformers shall provide feedback signal

to regulate torque during start up and to prevent overload conditions while motor is running. Starter shall have starting current of 300 percent of full load amps for thirty seconds, bypass/isolation contactor, and three phase thermal overload relay.]

2.8.3.3 Auxiliary Contacts

Each controller shall be provided with a minimum of three auxiliary contacts which can be easily changed from normally open to normally closed. Where indicated on the drawings, a fourth auxiliary contact and red and green indicating lights shall be provided.

2.8.3.4 Overload Relays

****

NOTE: The standard NEMA Class 20 overload relay operates at 600 percent of its rating after a maximum of 20 seconds. Other standards are Class 10 and Class 30, operating at a maximum of 10 and 30 seconds. This may be required for special applications.

****

Except as otherwise indicated, each controller shall be provided three NEMA Class 20 thermal overload relays with external manual reset. Prior to shipment of the control centers, the Contracting Officer will furnish the ratings of the heater elements to be installed in the relays by the Contractor.

2.8.3.5 [Individual Control Transformers

****

NOTE: Delete this paragraph as well as requirement for spare control transformer when a single control transformer for the motor control center is mounted in a unit compartment or external control source is provided.

Primary fuses for individual control transformers are given as an option. For less than 50 VA, they are not required or desired. Please refer to NFPA 70 section 430-72(c).

****

Where 120 volt ac control of contactors is indicated or required, individual control transformer shall be provided on the line side of the unit disconnect. The control transformers shall be rated 480-120 volts and shall conform to the requirements for control transformers in NEMA ST 1. Control transformers shall have adequate volt-ampere capacity for the control functions indicated. Transformers shall be installed [without] [with] primary fuses. [Primary fuses shall be Class J.] Except as otherwise indicated on the drawings, each control transformer shall be provided with a fuse in one secondary lead and shall have the other secondary lead grounded.]

2.8.3.6 [Voltage Fault Protection

****

NOTE: Voltage fault protection requirements should

be evaluated and this paragraph deleted when not required.
****

Where shown, starters shall be provided with protection against [voltage faults,] [phase unbalance,] [phase loss,] [phase reversal,] [undervoltage] [and overvoltage]. Upon sensing one of these faults, the protector shall de-energize the starter. The protector shall use a combination of voltage and phase-angle sensing to detect phase loss even when regenerated voltages are present. The protector shall be connected to the load side of the motor circuit disconnect. The protector shall have an adjustable line voltage trip level, adjustable trip delay, automatic reset [and manual reset by an external normally closed push-button,] and Double Pull Double Throw (DPDT) output contacts. Protector operation shall have repeatability of +1 percent of set point, maximum, and a dead band of 2 percent maximum. Protector shall have green indicator to show normal status and red indicator to show tripped status. Indicators will be visible through the compartment door, when LED's are used protector shall be covered with a clear unbreakable cover, when lamps are used they shall have nameplates and be grouped with other indicating lights.]

2.8.3.7 Control Circuit Disconnects

****
NOTE: The requirement for disconnect of the control circuit when the unit compartment is open complies with NFPA 70 Article 430 F section 430-74. Generally, manufacturers do not disconnect control voltage except when racking out the starter unit, meeting California code, but not NFPA as currently written. With racking, control circuit voltage is present when the unit compartment is open, which may be a safety risk. This paragraph is a specialized requirement to avoid such a safety hazard. Specific designs may require a variance. There are available high density pull apart terminals in the unit compartments to disconnect control voltage, after the unit is open. The latter meets the intent of NFPA, but not the letter. The designer shall investigate specific project requirements for interlocking and safety, and modify this paragraph accordingly.
****

Control circuit power shall disconnect when the unit compartment is opened.

2.8.4 Molded Case Circuit Breakers in Unit Compartments

Molded case circuit breakers for installation in unit compartments shall meet the requirements of paragraph MOLDED CASE CIRCUIT BREAKERS above.

2.8.5 Panelboards for Motor Control Centers

Panelboards shall meet the requirements of paragraph PANELBOARDS.

2.8.6 Distribution Transformers

Dry type transformers for power and lighting loads shall be furnished with voltage and kVA ratings as indicated on the drawings. The transformers

shall conform to the requirements for general-purpose transformers in NEMA ST 20. Each transformer shall be protected on the primary side with a molded case circuit breaker as indicated on the drawings. [Transformers shall be drawout type.]

2.8.7 [Ground Detector Indicator

****

NOTE: Ground detectors requirements should be evaluated and this paragraph deleted when not required.

****

Ground-detector indicator (GDI) shall be rated 120-volts; have three lamps, one per phase, three 480-120 volt transformers connected delta-wye, adjustable loading resistor for balancing capacitive charging current, and push-to test-switch. GDI shall provide visual indication of a single ground-fault on any phase (A, B, or C) of a three-phase, three-wire ungrounded power system. When no phase is grounded, all lamps shall glow at partial brightness, giving long lamp life, the push-to test switch shall not affect the brightness of any lamp. When a single ground-fault occurs on any phase, the lamp that corresponds to the faulted phase shall be dark and the other two lamps shall glow at full brightness. The push-to-test switch shall cause all lamps to return to partial brightness, showing the GDI is functioning properly.]

2.8.8 Wiring for Motor Control Centers

All wiring shall meet the requirements of paragraph WIRING above. Provide heavy-duty clamp type terminals for terminating all power cables entering the control centers.

2.8.8.1 Contractor's Wiring

The Contractor's wiring shall be formed into groups, suitably bound together, properly supported and run straight horizontally or vertically. There shall be no splices in the wiring. The manufacturer's standard pressure-type wire terminations for connections to internal devices will be acceptable. Terminal blocks shall be added for wiring to devices having leads instead of terminals. Ring tongue indented terminals shall be used on all wires terminated on control terminal blocks for external or interpanel connections and at shipping splits. All stud terminals shall have contact nuts and either locking nuts or lockwashers.

2.8.8.2 External Connections

****

NOTE: For NEMA 3R enclosures power cables shall enter from the bottom.

****

Power and control cables will enter the control centers at the [bottom] [top] [where shown on the drawings]. [Where power and control entry points are not shown, and terminal blocks are not given on the drawings, the Government will furnish this information to the Contractor after award of contract.]

2.8.8.3 Terminal Blocks

Terminal blocks shall meet the requirements of paragraph TERMINAL BLOCKS above. In no case shall the terminals provided for circuit breakers or contactors accommodate less than the number or size of conductors shown on the drawings. Special attention shall be given to wiring and terminal arrangement on the terminal blocks to permit the individual conductors of each external cable to be terminated on adjacent terminal points.

2.8.9 [Control Transformers

****
NOTE: Delete when individual control transformers are specified or external control circuit is provided.
****

Control transformers for several starter units shall be mounted in a separate compartment and its primary windings shall be connected to the main bus through a molded case circuit breaker of suitable rating. The control transformers shall be rated 480-120 volts and shall conform to the requirements for control transformers in NEMA ST 1. Control transformers shall have adequate volt-ampere capacity for the control functions indicated and an additional 10 percent capacity. Transformers shall be installed without primary fuses. Except as otherwise indicated on the drawings, each unit compartment shall provide a fuse for control power in one secondary lead and shall have the other secondary lead grounded. 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.]

2.8.10 Accessories and Control Devices

****
NOTE: Retain only paragraphs for accessories actually used for a given procurement.
****

Control accessories shall be provided, and shall be suitable for mounting on the front of, or inside, the control centers as indicated on the drawings. Control accessories shall meet the applicable requirements of NEMA ICS 2. Relays and other equipment shall be so mounted that mechanical vibration will not cause false operation.

2.8.10.1 Control Stations

Push-button stations and selector switches shall conform to NEMA ICS 2, shall be of the heavy-duty, oil-tight type, rated 600 volts ac, and have a contact rating designation of A600. Switches shall be provided with escutcheon plates clearly marked to show operating positions. [Sufficient contact blocks shall be provided to make up the electrically separate contacts required for lead-lag selector switches.]

2.8.10.2 LED Indicating Lights

Red and green LED's shall be furnished where shown on the drawings, indicating contact "open" and "closed" position. The LED's shall be accessible and replaceable from the front of the control center through a finished opening in the compartment door. The LED assemblies shall be of

the heavy duty oiltight, watertight, and dusttight type.

2.8.10.3 Control Relays

Control relays shall be of the electrically operated, magnetically held, self-reset, open type, suitable for mounting inside the starter compartments, and shall be [125-volt dc] [120-volt ac]. Contacts shall be as indicated on the drawings and shall have a contact rating designation of A600 or N600, as required, in accordance with NEMA ICS 2.

2.8.10.4 Timing Relays

Timers shall be pneumatic type. They shall be suitable for mounting inside the control center and shall be rated 120 volts ac, 60 Hz. Instantaneous and time delay contacts shall be provided as indicated on the drawings, and shall have a contact rating designation of A600 or N600, as required, in accordance with NEMA ICS 2. Means shall be provided for manual adjustment over a range as indicated on the drawings.

2.8.10.5 Alternators

Alternators 120-volt, 60 Hz, single-phase, open type, suitable for mounting inside of control center as indicated. Alternators shall automatically cycle two motor starters in such a manner that No. 1 will lead and No. 2 will lag during the first cycle, and during the second cycle No. 2 will lead and No. 1 will lag, and the third cycle will repeat the first cycle. The duration of a cycle will be determined by an [external device] [adjustable time delay]. Contacts shall have a minimum contact rating designation of A600 or N600, as required, in accordance with NEMA ICS 2.

2.8.10.6 Elapsed-Time Meters

Hour-indicating time meters shall have 6- digit registers with counter numbers at least 6 mm 1/4 inch high. White numbers on black backgrounds shall provide hour indication with the last digit in contrasting colors to indicate tenths of an hour. The enclosure shall be 90 mm 3-1/2 inches square and dust resistant. Operating voltage shall be 120 volts ac. They shall be of the nonreset type.

2.8.11 Feeder Tap Units

Feeder tap units shall be provided as indicated on the drawings.

2.8.12 Metering Section

Metering section shall be provided with instruments as indicated on the drawings.

2.8.12.1 Instrument Transformers

All transformers used for metering shall meet the requirements of NEMA/ANSI C12.11 and IEEE C57.13. Voltage transformers shall be protected with removable primary and secondary fuses. Fuses shall be installed in each ungrounded lead and located adjacent to the transformers in an easily accessible place. If cable connections to current transformer primary are required, terminals of an approved solderless type and proper size shall be furnished. If current transformers are connected to buses, proper connections shall be furnished, complete with bolts, nuts, washers and

other accessories.

2.8.12.2 Ammeters

Switchboard type ammeter shall be provided where indicated on the drawings. Ammeter, range 0 to [_____] amperes, complete with selector switch having off position and positions to read each phase current. Meters shall be long scale 175 mm 6.8 inches), semiflush rectangular, indicating type mounted at eye level.

2.8.12.3 Voltmeters

Switchboard type voltmeter shall be provided where indicated on the drawings. Voltmeter, range 0 to 600 volts, complete with selector switch having off position and positions to read each phase to phase voltage. Meters shall be long scale 175 mm 6.8 inches, semiflush rectangular, indicating type mounted at eye level.

2.8.12.4 Watthour Meters

Watthour meters shall conform to ANSI C12.1 and NEMA/ANSI C12.10, except numbered terminal wiring sequence and case size may be the manufacturer's standard. Watthour meters shall be of the drawout switchboard type having a 15-minute, cumulative form, demand register meeting NEMA C12.4 and provided with not less than two and one-half stators. [Watthour demand meters shall have factory installed electronic pulse initiators meeting the requirements of ANSI C12.1.]

2.8.12.5 Switches

All metering switches shall be of the rotary switchboard type with handles on the front and operating contact mechanisms on the rear of the panels. Control switches shall be suitable for operation on 600-volt AC or 250-volt DC circuits. All such switches shall be capable of satisfactorily withstanding a life test of at least 10,000 operations with rated current flowing in the switch contacts. Selector switches shall be maintained-contact type with the required number of positions, and shall have round notched, or knurled handles. Ammeter switches shall not open the secondary circuits of current transformers at any time. Instrument switches for potential selection shall have oval handles.

2.8.13 [Power-Factor-Correction Capacitors

****

NOTES: Power factor correction capacitors should not be used on the load side of solid state starters. Motor control center manufacturers do not normally contact the motor manufacturers, so where possible the designer shall show KVAR ratings on the drawings, coordinating these requirements with actual motors used.

When power factor correction is not needed, delete this paragraph.

****

Three-phase, delta-connected capacitors for power factor improvement shall be rated [_____] volts, 60 Hz. [Capacitors shall have KVAR capacity as shown on the drawings] [The capacitor KVAR capacity shall be selected to

achieve no less than [_____] percent leading nor more than [_____] percent lagging power factor at nameplate value of motor full load current. The KVAR capacity of the capacitors shall not be greater than that recommended by the motor manufacturer or if no such recommendation exists, that value which gives with a lagging power factor at no-load.] If size permits, the capacitors shall be mounted in an adjacent compartment, or otherwise shall be mounted separately and connected to the motor at the motor terminal box. [For reduced voltage starters, the capacitors shall be separately switched with a time-delayed contactor rated according to NEMA ICS 2 for capacitor switching.]]

2.8.14 [Space for Mounting PLC's

****
NOTE: Delete this paragraph when PLC's are not used.
****

Space for mounting of Programmable Logic Controllers (PLC's) shall be provided as indicated on the drawings.]

2.9 SWITCHBOARDS

****
NOTES: The switchboard specified below is not intended for applications where the available fault current is above 65,000 amps. Where drawout-type breakers, and high short circuit current ratings are desired, Section 26 22 00.00 10 480-VOLT STATION SERVICE SWITCHGEAR AND TRANSFORMERS should be used.

The short-circuit current rating assigned to the switchboard shall be in accordance with NEMA PB 2.
****

The switchboards shall be dead-front switchboards conforming to NEMA PB 2 and labeled under UL 891. The switchboards shall be completely enclosed self-supporting metal structures with the required number of vertical panel sections, buses, molded-case circuit breakers, [and other devices] as shown on the drawings. Switchboards shall be fully rated for a short-circuit current of [14,000] [22,000] [65,000] [_____] symmetrical amperes RMS AC.

2.9.1 Enclosure

****
NOTE: Mounting sills should be included for all new construction to provide structural integrity. NEMA PB2 90" height includes these sills.
****

Each switchboard enclosure shall be NEMA type [2] [3R], built with selected smooth sheet steel panels of not less than 1.9 mm No. 14 gage. Exposed panels on the front and ends shall have bent angle or channel edges with all corner seams welded and ground smooth. The front outside surfaces shall not be drilled or welded for the purpose of attaching wires or mounting devices if such holes or fastenings will be visible from the front. The front panels shall be made in sections flanged on four sides and attached to the framework by screws and arranged for ready removal for inspection or maintenance. [Rear access to the bus and device connections

shall be provided.] Ventilating openings shall be provided as required and shall preferably be of the grille type. All ventilating openings shall be provided with corrosion-resistant insect-proof screens on the inside. [Each switchboard shall be provided with a channel iron base at front, rear, and sides, with exposed ends covered by welded steel plates. Grout holes shall be provided. The switchboard sections shall be bolted to the base.] [Switchboards shall be mounted as shown on the drawings and mounting materials shall be furnished as indicated.] All interior and exterior steel parts shall be treated to inhibit corrosion and shall be painted as specified in paragraph PAINTING.

2.9.2 Bus

****

NOTE: When either copper or aluminum bus is allowed the manufacturers will generally provide the less expensive aluminum. Use ASTM 317 when aluminum bus is permitted. Silver plating allows for a greater temperature rise on the bus.

****

All buses shall be of copper [or aluminum] and [all bolted splices and connections between buses and for extensions or taps for equipment] shall be tin or silver-plated [throughout]. Copper [or aluminum] bars and shapes for bus conductors shall conform to the applicable requirements of ASTM B187/B187M [, and ASTM B317/B317M]. All splices for field assembly shall be bolted with at least two bolts and shall employ the use of "Belleville" washers in the connection. Horizontal and vertical power buses have minimum current ratings as shown on the drawings. The buses shall be insulated for not less than 600 volts. Shop splices and tap connections shall be brazed, pressure-welded or bolted. All splices for field assembly shall be bolted. The buses shall be mounted on insulating supports of wet process porcelain, glass polyester, or suitable molded material, and shall be braced to withstand not less than [14,000] [22,000] [65,000] [_____] symmetrical amperes ac.

2.9.3 [Grounding Bus

****

NOTE: Delete this paragraph when not required.

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A copper [or aluminum] ground bus, rated not less than 300 amps, extending the entire length of the assembled structure, shall be mounted near the bottom of enclosure. A full clamp-type solderless copper or copper alloy lug for No. 2/0 AWG stranded copper cable shall be provided at each end of the bus for connection to the station grounding system.]

2.9.4 Components

Each switchboard shall be equipped with molded-case circuit breakers conforming to paragraph MOLDED CASE CIRCUIT BREAKERS and with frame sizes, trip ratings, and terminal connectors for attachment of outgoing power cables as shown on the drawings. The circuit breakers shall be individually stationary mounted, as shown on the drawings, and shall be operable and removable from the front. Where shown on the drawings, circuit breakers shall be enclosed in individual compartments. [The group-mounted circuit breakers shall be provided complete with bus work in an integrated assembly on the switchboard and shall conform to the

applicable requirements of paragraph PANELBOARDS.]

2.10 PANELBOARDS

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NOTE: The short-circuit current rating assigned to the panelboard shall be in accordance with NEMA PB 1.
****

Panelboards shall consist of assemblies of molded-case circuit breakers with buses and terminal lugs for the control and protection of branch circuits to motors, heating devices and other equipment operating at 480 volts ac or less. Panelboards shall be UL 67 labeled. "Loadcenter" type panels are not acceptable. Panelboards shall be designed for installation in surface-mounted or flush-mounted cabinets accessible from the front only, as shown on the drawings. Panelboards shall be fully rated for a short-circuit current of [14,000] [22,000] [_____] symmetrical amperes RMS ac.

2.10.1 Enclosure

Enclosures shall meet the requirements of UL 50. All cabinets shall be fabricated from sheet steel of not less than 3.5 mm No 10 gage if flush-mounted or mounted outdoors, and not less than 2.7 mm No 12 gage if surface-mounted indoors, with full seam-welded box ends. Cabinets mounted outdoors or flush-mounted shall be hot-dipped galvanized after fabrication. Cabinets shall be painted in accordance with paragraph PAINTING. Outdoor cabinets shall be of NEMA 3R raintight and [conduit hubs welded to the cabinet] [a removable steel plate 6 mm 1/4 inch thick in the bottom for field drilling for conduit connections.] Front edges of cabinets shall be form-flanged or fitted with structural shapes welded or riveted to the sheet steel, for supporting the panelboard front. All cabinets shall be so fabricated that no part of any surface on the finished cabinet shall deviate from a true plane by more than 3 mm 1/8 inch. Holes shall be provided in the back of indoor surface-mounted cabinets, with outside spacers and inside stiffeners, for mounting the cabinets with a 13 mm 1/2 inch clear space between the back of the cabinet and the wall surface. Flush doors shall be mounted on hinges that expose only the hinge roll to view when the door is closed. Each door shall be fitted with a combined catch and lock, except that doors over 600 mm 24 inches long shall be provided with a three-point latch having a knob with a T-handle, and a cylinder lock. Two keys shall be provided with each lock, and all locks shall be keyed alike. Finished-head cap screws shall be provided for mounting the panelboard fronts on the cabinets. Enclosure shall have nameplates in accordance with paragraph NAMEPLATES. Directory holders, containing a neatly typed or printed directory under a transparent cover, shall be provided on the inside of panelboard doors.

2.10.2 Buses

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NOTE: When either copper or aluminum bus is allowed the manufacturers will generally provide the less expensive aluminum. Use ASTM 317 when aluminum bus is permitted. Silver plating the bus allows for higher temperature rise and is not generally required.
****

All panelboards shall be of the dead-front type with buses and circuit breakers mounted on a plate or base for installation as a unit in a cabinet. All buses shall be of copper [or aluminum] [and shall be tin or silver-plated throughout]. Copper [or aluminum] bars and shapes for bus conductors shall conform to the applicable requirements of ASTM B187/B187M [, and ASTM B317/B317M]. The sizes of buses and the details of panelboard construction shall meet or exceed the requirements of NEMA PB 1. Suitable provisions shall be made for mounting the bus within panelboards and adjusting their positions in the cabinets. Terminal lugs required to accommodate the conductor sizes shown on the drawing, shall be provided for all branch circuits larger than No. 10 AWG. A grounding lug suitable for 1/0 AWG wire shall be provided for each panelboard.

2.10.3 Components

Each branch circuit, and the main buses where so specified or shown on the drawings, shall be equipped with molded-case circuit breakers having overcurrent trip ratings as shown on the drawings. The circuit breakers shall be of a type designed for bolted connection to buses in a panelboard assembly, and shall meet the requirements of paragraph MOLDED CASE CIRCUIT BREAKERS. Circuit breakers of the same frame size and rating shall be interchangeable. [Bell alarm contacts shall be furnished as indicated on the drawings and shall be wired to terminal blocks mounted in the cabinet. Terminal blocks shall conform to requirements of paragraph TERMINAL BLOCKS.]

2.11 FACTORY TESTS

Each item of equipment supplied under this contract shall be given the manufacturer's routine factory tests and tests as specified below, to insure successful operation of all parts of the assemblies. All tests required herein shall be witnessed by the Contracting Officer unless waived in writing, and no equipment shall be shipped until it has been approved for shipment by the Contracting Officer.

a. Submit [6] [_____] copies of manufacturer's routine factory test procedures and production line tests for all motor control centers and switchboards, within a minimum of [14] [_____] days prior to the proposed date of tests. Notify the Contracting Officer a minimum of [14] [_____] days prior to the proposed date of the tests so that arrangements can be made for the Contracting Officer to be present at the tests.

b. The factory test equipment and the test methods used shall conform to the applicable NEMA Standards, and shall be subject to the approval of the Contracting Officer. Submit [6] [_____] complete reproducible copies of the factory inspection results and [6] [_____] complete reproducible copies of the factory test results in booklet form, including all plotted data curves, all test conditions, a listing of test equipment complete with calibration certifications, and all measurements taken.

c. Report shall be signed and dated by the Contractor's and Contracting Officer's Representatives. Reports of all witnessed tests shall be signed by witnessing representatives of the Contractor and Contracting Officer. The cost of performing all tests shall be borne by the Contractor and shall be included in the prices bid in the schedule for equipment.

2.11.1 Motor Control Centers Tests

2.11.1.1 Dielectric Tests

Each motor control center shall be completely assembled and given dielectric tests in accordance with NEMA ICS 1.

2.11.1.2 Operational Tests

The correctness of operation of each air circuit breaker [or motor circuit protector] and magnetic contactor and of all control devices, accessories and indicating lamps, shall be checked. These checks shall be made at rated voltage with power supplies to the main buses. All magnetic contactors shall also be checked for proper operation with power at 90 percent of rated voltage.

2.11.1.3 Short Circuit Tests

If the unit is not UL labeled for the specified short circuit, the Contractor may submit design tests demonstrating that satisfactory short-circuit tests, as specified in NEMA ICS 2, have been made on a motor control center of similar type of construction and having the same available short circuit current at the motor terminals, including any motor contributions, as the motor control centers specified to be furnished under these specifications.

2.11.2 Switchboards Tests

2.11.2.1 Production Tests

Each switchboard shall be completely assembled and given applicable production tests for assembled switchgear as specified in NEMA PB 2.

2.11.2.2 Short Circuit Tests

If the unit is not UL labeled for the specified short circuit, the Contractor may submit design tests demonstrating that satisfactory short-circuit tests have been made on a switchboard of similar type of construction and of the same short-circuit rating as the switchboards specified to be furnished under these specifications.

2.11.3 Panelboards Tests

Each panelboard shall be assembled with cabinet and front to the extent necessary to check the fit and provisions for installing all parts in the field. Each panelboard shall be given a dielectric test in accordance with NEMA PB 1. All circuit breakers shall be operated to check mechanical adjustments. All doors and locks shall be checked for door clearances and fits and the performance of lock and latches.

2.12 PAINTING

Interior and exterior steel surfaces of equipment enclosures shall be thoroughly cleaned and then receive a rust-inhibitive phosphatizing or equivalent treatment prior to painting. Exterior surfaces shall be free from holes, seams, dents, weld marks, loose scale or other imperfections. Interior surfaces shall receive not less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice. Exterior surfaces shall be primed, filled where necessary, and

given not less than two coats baked enamel with semigloss finish. Equipment located indoors shall be ANSI Light Gray, [and equipment located outdoors shall be ANSI [Light Grey] [Dark Gray].] All touch-up work shall be done with manufacturer's coatings as supplied under paragraph SPARE PARTS.

PART 3 EXECUTION (Not Applicable)

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NOTE: PART 3 will be used for construction contracts only; take care to prevent conflicts, gaps or omissions.

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-- End of Section --