Preparing Activity: NASA Superseding
UFGS-26 24 19.00 40 (November 2014)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
****

SECTION TABLE OF CONTENTS

DIVISION 26 - ELECTRICAL

SECTION 26 24 19.00 40

MOTOR CONTROL CENTERS

05/19

PART 1 GENERAL

1.1 UNIT PRICES
1.2 REFERENCES
1.3 SUBMITTALS
1.4 QUALITY CONTROL
1.4.1 Regulatory Requirements
1.4.2 Qualifications
1.4.3 Predictive Testing And Inspection Technology Requirements
1.4.4 Standard Products
1.5 DELIVERY, STORAGE, AND HANDLING
1.6 MAINTENANCE
1.6.1 Accessories and Tools
1.6.2 Spare Parts

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION
2.1.1 Compliance
2.1.2 Coordination
2.1.3 Nameplates
2.2 FABRICATION
2.2.1 Ratings
2.2.2 Enclosures
2.2.2.1 Arc Resistant Enclosure
2.2.2.2 Unit Compartments
2.2.2.3 Motor Control Center Doors and Covers
2.2.2.4 Horizontal Wireways
2.2.2.5 Vertical Wireways
2.2.2.6 Sills
2.2.2.7 NEMA 3R Enclosures
2.2.2.8 Shutters
2.2.2.9 Thermostatically Controlled Strip Heaters
2.2.3 Buses

2.2.3.1 Horizontal Bus
2.2.3.2 Vertical Bus
2.2.3.3 Ground Bus
2.2.3.4 Neutral Bus
2.2.4 Painting
2.3 EQUIPMENT
2.3.1 Connections
2.3.2 Molded Case Circuit Breakers
2.3.2.1 Trip Units
2.3.2.2 480-Volt AC Circuits
2.3.2.3 120/240-Volt AC Circuits
2.3.2.4 125-Volt DC Circuits
2.3.3 Wiring
2.3.4 Terminal Blocks
2.3.4.1 Short-Circuiting Type
2.3.4.2 Load Type
2.3.4.3 Marking Strips
2.3.5 Space Heaters
2.4 COMPONENTS
2.4.1 Combination Starters
2.4.1.1 Magnetic Contactors
2.4.1.2 Reduced Voltage Starters
2.4.1.3 Variable Frequency Controllers
2.4.1.4 Auxiliary Contacts
2.4.1.5 Overload Relays
2.4.1.6 Individual Control Transformers
2.4.1.7 Voltage Fault Protection
2.4.1.8 Control Circuit Disconnects
2.4.2 Panelboards for Motor Control Centers
2.4.3 Distribution Transformers
2.4.4 Ground Detector Indicator
2.4.5 Wiring for Motor Control Centers
2.4.5.1 Contractor's Wiring
2.4.5.2 External Connections
2.4.5.3 Terminal Blocks
2.4.6 Control Power
2.4.7 Accessories and Control Devices
2.4.7.1 Control Stations
2.4.7.2 LED Indicating Lights
2.4.7.3 Control Relays
2.4.7.4 Timing Relays
2.4.7.5 Alternators
2.4.7.6 Elapsed-Time Meters
2.4.8 Feeder Tap Units
2.4.9 Metering Section
2.4.9.1 Instrument Transformers
2.4.9.1.1 Current Transformers (CT)
2.4.9.1.2 Potential Transformers
2.4.10 Power-Factor-Correction Capacitors
2.4.11 Space for Mounting PLC's
2.5 TESTS, INSPECTIONS, AND VERIFICATIONS
2.5.1 Motor Control Centers Tests
2.5.1.1 Dielectric Tests
2.5.1.2 Operational Tests
2.5.1.3 Short Circuit Tests
2.5.1.4 Test Results

PART 3 EXECUTION

3.1 INSTALLATION
3.2 FIELD TESTING
3.2.1 Acceptance Tests
3.3 CLOSEOUT ACTIVITIES

-- End of Section Table of Contents --

Preparing Activity: NASA

Superseding
UFGS-26 24 19.00 40 (November 2014)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023

SECTION 26 24 19.00 40

MOTOR CONTROL CENTERS
05/19

NOTE: This guide specification covers the requirements for motor control centers.

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 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.

Include suitable drawings showing the general arrangement and single-line diagram of each motor control center and panelboard with the procurement specifications. Ensure the drawings 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 guide 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, use NEMA Class I. This guide specification may be modified for NEMA Class I motor control centers by deleting the following paragraphs from PART 2:

WIRING

TERMINAL BLOCKS

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

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

Wiring for Motor Control Centers

Alternators

Operational Tests

****

1.1 UNIT PRICES

****

NOTE: Drafts of specifications submitted to higher authority for review and approval consists 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. Modify this example to fit the individual contract requirements. Enter dissimilar motor control centers, switchboards and panelboards separate bid items.

SECTION B
SUPPLIES/SERVICES AND PRICES

ITEM	DESCRIPTION	EST QTY	U/M	UNIT PRICE	AMOUNT
0001	480-VOLT, 3-PHASE, UNIT MOTOR CONTROL CENTER (NO. _____)	1	LS	EACH	$_____
000X	480-VOLT, 3-PHASE, MOTOR CONTROL CENTER (NO. _____)	1	LS	EACH	$_____
000X	480-VOLT, 3 PHASE, POWER DISTRIBUTION SWITCHBOARD (NO. _____)	1	LS	EACH	$_____
000X	480-VOLT, 3-PHASE, POWER DISTRIBUTION PANELBOARD (NO. _____)	1	LS	EACH	$_____
000X	ACCESSORIES AND SPARE PARTS	1	LOT	XXXX	$_____
000X	CONTRACT DATA (PART 1, THE SCHEDULE) (SEE DD FORM 1423, EXHIBIT B)	XXX	XXX	NSP	XXXXXXXXXXX

****

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 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)

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)
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2023) National Electrical Safety Code
IEEE C37.20.7	(2017; Corr 2021) Guide for Testing Switchgear Rated Up to 52 kV for Internal Arcing Faults
IEEE C57.12.01	(2020) General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid-Cast and/or Resin-Encapsulated Windings
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers
IEEE C63.2	(2009) Standard for Electromagnetic Noise and Field Strength Instrumentation, 10 Hz to 40 GHz - Specifications
IEEE C63.4	(2014) American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power

Equipment and Systems

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

RCBEA GUIDE	(2004) NASA Reliability Centered Building and Equipment Acceptance Guide

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA AB 3	(2013) Molded Case Circuit Breakers and Their Application
NEMA ICS 1	(2022) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2020) 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 ST 20	(2014) Dry-Type Transformers for General Applications

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 44	(2018; Reprint May 2021) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 506	(2017; Reprint Jan 2022) UL Standard for Safety Specialty Transformers
UL 508	(2018; Reprint Jul 2021) UL Standard for Safety Industrial Control Equipment
UL 845	(2021) UL Standard for Safety Motor Control Centers
UL 1063	(2017; Reprint Jun 2022) 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.
****

****
NOTE: For DB, delete 01 33 00 SUBMITTAL PROCEDURES, and replace with 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES, and 01 33 10.05 20 DESIGN SUBMITTAL PROCEDURES.
****

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

Motor Control Center Equipment Drawings

SD-03 Product Data

Motor Control Center Equipment[; G[, [____]]]

SD-06 Test Reports

Factory Test Procedures[; G[, [____]]]

Factory Test Results[; G[, [____]]]

Final Test Reports[; G[, [____]]]

Acceptance Tests[; G[, [____]]]

[SD-07 Certificates

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

Motor Control Center Certification[; G[, [____]]]

] SD-11 Closeout Submittals

Warranty[; G[, [____]]]

Manufacturer's Instructions[; G[, [____]]]

1.4 QUALITY CONTROL

1.4.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, IEEE C2 unless more stringent requirements are specified or indicated.

1.4.2 Qualifications

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products which have been in satisfactory commercial or industrial use for 2 years prior to bid opening. Ensure the 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product has been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer.

1.4.3 Predictive Testing And Inspection Technology Requirements

****
NOTE: The Predictive Testing and Inspection (PT&I) tests prescribed in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS are MANDATORY for all [NASA] [_____] assets and systems identified as Critical, Configured, or Mission Essential. If the system is non-critical, non-configured, and not mission essential, use sound

engineering discretion to assess the value of adding these additional test and acceptance requirements. See Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS for additional information regarding cost feasibility of PT&I.
****

This section contains systems and/or equipment components regulated by NASA's Reliability Centered Building and Equipment Acceptance Program. This program requires the use of Predictive Testing and Inspection (PT&I) technologies in conformance with RCBEA GUIDE to ensure building equipment and systems installed have been installed properly and contain no identifiable defects that shorten the design life of a system and/or its components. Satisfactory completion of all acceptance requirements is required to obtain Government approval and acceptance of the Contractor's work.

Perform PT&I tests and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

1.4.4 Standard Products

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

1.5 DELIVERY, STORAGE, AND HANDLING

****
NOTE: ABC phasing should be in accordance with NFPA 70 front-to-back, top-to-bottom, and left-to-right. Avoid alternate phasing 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.
****

Ship the motor control center equipment as completely assembled and wired as feasible so as to require a minimum of installation work. Ensure each shipping section is properly match marked to facilitate reassembly. Provide equipment with removable lifting channels with eye bolts for attachment of crane slings to facilitate lifting and handling.

Carefully pack and ship separately any relay or other device which cannot withstand the hazards of shipment when mounted in place on the equipment. Mark these devices with the number of the panel which they are to be mounted on and fully identified.

Wrap all finished painted surfaces and metal work to protect from damage during shipment. Prepare all parts for shipment so that slings for handling may be attached readily while the parts are in a railway car or transport truck.

Carefully package and clearly mark all spare parts and accessories.[

Ensure sections of equipment crated for shipment are of such size, including crates, that they will pass through a [_____] by [_____]-meter -foot hatch opening and a [_____] by [_____]-meter-foot wall opening.]

Locate motor control center equipment in well ventilated areas, free from excess humidity, dust and dirt and away from hazardous materials with ambient temperature between minus 30 and plus 40 degrees Cminus 22 and 104 degrees F. Ensure motor control center equipment is protected to prevent moisture from entering enclosure. Handle motor control center equipment in accordance with NEMA ICS 2.

1.6 MAINTENANCE

1.6.1 Accessories and Tools

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

1.6.2 Spare Parts

****

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

****

Furnish a list of spare parts as recommended by the manufacturer for the equipment. Ensure all spare parts are of the same material and workmanship, meet the same requirements, and are interchangeable with the corresponding original parts furnished.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

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

Submit motor control center equipment drawings, including all motor control units and protective devices. Provide a single-line diagram, equipment list and nameplate schedule. Includes 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. Ensure drawings show the general arrangement and overall dimensions of the motor control centers space requirements, details of any floor supports to be embedded in concrete and provisions for conduits for external cables. [Include within the NEMA Class II[S] motor control center drawings a connection diagram with wire designations and schematic diagrams to illustrate operation of associated motor unit controls.] Include complete wiring diagrams for each motor control center. [Provide wiring diagrams in a form showing physical arrangement of the control center with interconnecting wiring shown by lines or by terminal designations (wireless).]

****

NOTE: The intent of this submittal 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, specify NEMA Class IIS.

Should this specification be used in procurement of NEMA Class I equipment, the drawing packages are less involved and the second and fourth sentences deleted from this paragraph.

****

2.1.1 Compliance

****

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 to 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 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 generally provides better protection for motors, controllers, and circuit conductors than the thermal-magnetic type. Specify one or the other so that all bids are on the same basis. Generally, specify thermal magnetic breakers 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 guide 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 is shown on the contract drawings. Any modifications of the equipment arrangement or device requirements as shown on the drawings is subject to the approval of the Contracting Officer. If any conflicts occur necessitating departures from the drawings, submit details of and reasons for departures and approved prior to implementing any change. Completely assemble all equipment at the factory. The motor control centers may be disassembled into sections, if necessary, for convenience of handling, shipping, and installation.

2.1.3 Nameplates

Provide nameplates of laminated sheet plastic in accordance with ASTM D709. Ensure nameplates are melamine plastic 4 mm 1/8 inch thick, black matte finish with white center core and square corners. [Fasten the nameplates to the equipment in proper positions with anodized round-head screws.] Accurately align lettering and engrave into the core. Lettering is a minimum 13 mm 1/2-inch high normal block style. Nameplate designations are in accordance with lists on the drawings, and as a minimum provide for the following equipment:

a. Motor Control Centers

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

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

2.2 FABRICATION

2.2.1 Ratings

Provide equipment with the following ratings:

****

NOTE: Select "as indicated" if there are multiple motor control centers with details of each shown on drawings. Most motor control centers will be 3-wire, but might be a 4-wire design for equipment that supplies other than motor loads.

****

a. Voltage rating: [480Y/277][208Y/120][_____] volts AC, [3][4]-wire [three-phase, [3][4]-wire][as indicated].

b. Continuous current rating of the main bus: [_____ amperes][as indicated].

c. Short-circuit current rating: [_____ rms symmetrical amperes][as indicated].

d. UL listed and labeled[for its intended use][as service entrance equipment].

2.2.2 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. Ensure that the NEMA type specified meets design requirements.

****

Each motor control center consists 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 sections are nominally 2250 mm 90 inches high and [330.2][406.4][508][ ] mm [13][16][20][_____] inches deep with buses, control wiring, control transformers, small power transformers, terminal blocks, line terminals, cable supports, and clamps accessible from the front. Enclosure is NEMA Type [1] [1A gasketed] [12] [3R]. Fabricate the motor control centers from smooth select steel sheets shaped and reinforced to form rigid free-standing structures. Ensure metal thickness for enclosures is no less than specified in NEMA ICS 6 without exception. Fabricate and bolt vertical edges of sections exposed to view so that the joints do not pass a 1.6 mm 1/16 inch gauge. [Design each structure for addition of future sections.]Equip vertical sections with full length vertical isolating barriers between sections. Make provisions for leveling the assembled motor-control center sections and bolting them together so that they form a contiguous structural enclosure.

Provide removable 4.8 mm gauge 7 gauge lifting angles on the top of each section, extending the entire width of the section, capable of supporting the entire weight of the motor control center section without distortion. Provide base channels with holes to facilitate floor mounting and leveling.

2.2.2.1 Arc Resistant Enclosure

****

NOTE: Determine if an arc-resistant design will be specified for the installation. A selection of arc-resistant equipment can affect the installation design. Arc-resistant switchgear is tested and certified to IEEE C37.20.7, and is intended to provide added protection for internal arcing faults. Select Type 1 if arc protection is only required for the freely accessible front of the enclosure. Select Type 2 if arc protection is required for freely accessible front, sides and rear of the enclosure. Select the 'B' suffix for additional protection applied to compartments designated as low voltage control or instrumentation compartments. Select the 'C' suffix where isolation

from the effects of an internal arcing fault is desired between all adjacent compartments within a switchgear assembly. Most manufacturers produce Type 2B as a standard product, which could increase the switchgear cost by about 20 percent. Review IEEE C37.20.7 for additional information.

Delete this section if Arc Resistant enclosure is not required.

****

Provide arc resistant Type [1[B][C]][2[B][C]] enclosure tested in accordance with IEEE C37.20.7.

2.2.2.2 Unit Compartments

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

Ensure compartments for future motor-control units are complete with hardware, buses, and hinged doors ready to receive future draw-out units. Compartments for spare motor-control units are complete with buses, hinged doors, and draw-out units but without load terminal connections. Spare spaces are complete with buses and screwed-on front cover plates.

2.2.2.3 Motor Control Center Doors and Covers

Provide each unit compartment, including blank compartments for future use, with either a flange-formed or a rolled-edge door. Mount each door on fully-concealed or continuous full-length piano-type hinges and provide with positive fasteners. Prevent door sag by proper alignment of hinges made of sufficiently strong material. Interlock the door fastenings to prevent opening when the equipment is energized. Ensure the external operating handle clearly indicates whether the equipment is in an "ON", "OFF" or "TRIPPED" position.

2.2.2.4 Horizontal Wireways

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

2.2.2.5 Vertical Wireways

Provide vertical wireways in all vertical sections. Connect vertical wireways with horizontal wireways at the top and bottom and be a minimum 100 mm 4 inches wide. Provide barriers in sections containing both ac and dc circuits. Provide doors on each vertical wireway with the exposed surface of any door not deviating more than 1.5 mm 1/16 inch from a true plane. Provide cable tie supports in the vertical wireway to hold cable and wiring in place

[If communication wiring is required, add metal shielding in the vertical wiring trough to provide isolation from power and control wiring within the vertical wiring trough.

][2.2.2.6 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 not be exceeded unless space for operator to stand on a pad is provided.

****

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

][2.2.2.7 NEMA 3R Enclosures

****

NOTE: Enclosures covered by this specification are 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. Verify the latter styles of enclosures comply with NFPA 101 for means of egress and lighting.

Delete this section if NEMA 3R Enclosures are not required.

****

Provide a non-walk in, NEMA Type 3R, rainproof enclosure motor control center. The outside enclosure consists of smooth select [steel sheets on a structural steel frame][stainless steel sheets on a stainless steel structural frame]. Provide full-length single or double doors with top and bottom bolts and a center latch operated by means of a keyed handle. Ensure steel sheets and doors are not less than 3.5 mm gauge No. 10 gauge thick. Doors have bent angle or channel edges with all corner seams welded and ground smooth. Assemble the motor control center within the enclosure with adequate gaskets and structure to assure a measure of vandal resistance. Ventilate openings and provide an effective insulating

air space of approximately 50 mm 2 inches below the roof of the structure which slopes from front to back for adequate drainage. Permit easy sealing of the outside edges of the control center base at the concrete surface with mastic compound. Provide two duplex receptacle units within the outer weatherproof enclosure.

[Furnish a 200-watt outdoor lighting fixture with globe and guard to light the front of the assembly. Ensure all lighting connections are watertight. Furnish a weatherproof switch installation 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 is "ac" rated, 15 amperes, 120/277 volts.] Wire the[lighting fixture and] receptacles to [120-volt external source as indicated][the 120-volt ac panelboard located in the control center], and run external wiring in rigid galvanized steel conduit.

]2.2.2.8 Shutters

Provide drawout units with shutters which close when the unit is withdrawn to isolate the vertical bus.

[2.2.2.9 Thermostatically Controlled Strip Heaters

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

Provide thermostatically controlled strip heaters as specified in paragraph SPACE HEATERS [in all motor control centers] [where indicated].

]2.2.3 Buses

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

NEMA ICS 1 allows a 65 degrees Celsius149 degrees Fahrenheit temperature rise on the buses, irrespective of the equipment used. UL 845 allows 65 degrees Celsius149 degrees Fahrenheit temperature rise only under certain conditions. In general this means all buses are plated and devices are UL labeled for the higher temperatures. If this is not the case, the UL standard for temperature rise is 50 degrees Celsius122 degrees Fahrenheit creating a conflict with NEMA. The designer should be aware of this difference. This guide specification references the UL standard and bases the rise on the exceptions it permits.
****

Ensure all buses are [[tinned][copper]][aluminum], and all bolted splices and connections between buses and for extensions or taps for equipment [are tin or silver-plated][are tin or silver-plated throughout]. [Copper][Aluminum] bars and shapes for bus conductors conform to the applicable requirements of ASTM B187/B187M[, and ASTM B317/B317M]. Bolt all splices for field assembly with at least two bolts and employ the use of "Belleville" washers in the connection. Base the bus ratings on a 65

degree Celsius149 degree Fahrenheit maximum temperature rise in accordance with UL 845 requirements. Ensure bus has a short-circuit current rating of not less than [42,000][65,000][100,000][_____] RMS symmetrical amperes. Support all bus work on wet process porcelain insulators, glass polyester, or suitable molded material.

2.2.3.1 Horizontal Bus

Provide each control center assembly 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. Drill the ends of horizontal buses for future extensions. [Fully insulate the main horizontal bus.]

2.2.3.2 Vertical Bus

Provide each vertical section 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, rate the vertical bus in that section the same as the main horizontal bus. Extend vertical buses from the horizontal bus to the bottom of the lowest available unit mounting space. Isolate the vertical bus from wireways and equipment in compartments.

[2.2.3.3 Ground Bus

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

Provide a [[tin-plated][copper]][aluminum] ground bus full width at the bottom of the motor control center line-up. Provide a full clamp-type solderless [copper][copper alloy] lug for No. [2/0][4/0][_____] AWG stranded copper cable at each end of the bus for connection to the grounding system. Ensure the ground bus is capable of carrying the rated short-circuit current available in the motor-control center.

][2.2.3.4 Neutral Bus

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

Furnish a [half] [fully] rated neutral bus continuous through the control center with appropriate capacity.

]2.2.4 Painting

Thoroughly clean the interior and exterior steel surfaces of equipment enclosures and then receive a rust-inhibitive phosphatizing or equivalent treatment prior to painting. Ensure exterior surfaces are free from holes, seams, dents, weld marks, loose scale or other imperfections. Interior surfaces receives not less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice. Prime exterior surfaces, fill where necessary, and give no less than two coats baked enamel with semigloss finish. Ensure equipment located indoors is ANSI Light Gray, [and equipment located outdoors is ANSI [Light Gray] [Dark Gray].] All touch-up work is done with manufacturer's coatings.

2.3 EQUIPMENT

2.3.1 Connections

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

2.3.2 Molded Case Circuit Breakers

Ensure molded case circuit breakers conform to the applicable requirements of UL 489. Provide manually-operated circuit breakers of the quick-make, quick-break, common trip type. Furnish automatic-trip breakers unless otherwise specified or indicated on the drawings. Provide the common-trip multipole circuit breakers having a single operating handle and a two-position on/off indication and with provisions for padlocking in the "Off" position. Provide personnel safety line terminal shields for each breaker. Ensure the circuit breakers are products of only one manufacturer, and interchangeable when of the same frame size. [Where indicated on the drawings, provide circuit breakers with shunt trip devices.] [Where indicated on the drawings, provide circuit breakers with bell alarm contacts that close on automatic operation only. Provide contacts suitable for [125] [____] volts dc and be reset when the breaker is reset.]

Size breakers as required for the continuous-current rating of the circuit. Provide the breaker class as required. 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.

Provide sufficient interrupting capacity maximum short-circuit current imposed on the circuit at the breaker terminals as indicated. Provide circuit breaker interrupting capacities with a minimum of 10,000 A and that conform to NEMA AB 3. Series rating of circuit breakers is not permitted.

Provide circuit breakers with temperature compensation for operation in an ambient temperature of 40 degrees C 104 degrees F. Provide circuit breakers that have root mean square (rms) symmetrical interrupting ratings sufficient to protect the circuit being supplied.

2.3.2.1 Trip Units

****

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. Indicate specific locations where solid state trips are required on the drawings.

NOTE: Coordinate circuit breaker setting requirements in this section with project requirements. If solid state trip circuit breakers with adjustable settings are specified ensure appropriate overcurrent protective device coordination study is included in project requirements.

****

Except as otherwise noted, provide the circuit breakers, of frame sizes and the trip unit ratings as shown on the drawings, with inverse-time thermal-overload protection and instantaneous magnetic short-circuit protection or solid state trip units. Provide [instantaneous magnetic trip units are adjustable][Solid state trip units equipped with adjustable [long time pick-up and delay],[short time pick-up and delay], [and ground fault pick-up and delay]] on frame sizes larger than [150][250][_____] amperes. [Set all protective devices in accordance with approved coordination study.][Set nonadjustable instantaneous magnetic trip units at approximately 10 times the continuous current ratings of the circuit breakers.]

2.3.2.2 480-Volt AC Circuits

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

2.3.2.3 120/240-Volt AC Circuits

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

2.3.2.4 125-Volt DC Circuits

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

2.3.3 Wiring

Provide NEMA Class [I][II], Type [A][BD][BT][C]. [Where Type C wiring is required, locate the master terminal blocks at the [top][bottom] of the vertical section.] Wire out combination starter units to split type terminal blocks for easy removal of the starter unit without disturbing either factory or field installed wiring. Ensure all control terminal boards are accessible from the front.

All control wire is stranded tinned copper switchboard wire with 600-volt flame-retardant insulation Type SIS meeting UL 44 or Type MTW meeting UL 1063, and passes the VW-1 flame tests included in those standards. Hinge wire has Class K stranding. Current transformer secondary leads cannot be smaller than No. 10 AWG. The minimum size of control wire is No. 14 AWG. Power wiring for 480-volt circuits and below is of the same type as control wiring and the minimum size is No. 12 AWG. Give special attention 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.

2.3.4 Terminal Blocks

Use molded or fabricated circuit terminal blocks for wiring with barriers, rated not less than 600 volts. Provide terminals with removable binding, fillister or washer head screw type. Ensure terminals are no less than No. 10 in size and having sufficient length and space for connecting at least two indented terminals for 10 AWG conductors to each terminal. The terminal arrangement is subject to the approval of the Contracting Officer. Modular, pull apart, terminal blocks are acceptable provided they are of the channel or rail-mounted type. Submit data showing that the proposed alternate accommodates the specified number of wires, are of adequate current-carrying capacity, and are constructed to assure positive contact between current-carrying parts.

2.3.4.1 Short-Circuiting Type

Provide short-circuiting type terminal blocks for all current transformer secondary leads with provision for shorting together all leads from each current transformer without first opening any circuit.

2.3.4.2 Load Type

Provide load terminal blocks rated no less than 600 volts and of adequate capacity for the conductors for NEMA Size 3 and smaller motor controllers and for other power circuits except those for feeder tap units. Provide the terminals of of the 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, use screws with hexagonal heads. Provide adequate contact surface and cross-section for conducting parts between connected terminals to operate without overheating. Each connected terminal has the circuit designation or wire number placed on or near the terminal in permanent contrasting color.

2.3.4.3 Marking Strips

Provide white or other light-colored plastic marking strips, fastened by screws to each terminal block, for wire designations. Mark the wire numbers with permanent ink. Provide reversible marking strips to permit marking both sides, or furnish two marking strips with each block. Provide marking strips that accommodate the two sets of wire numbers. Assigned a device designation to each device to which a connection is made in accordance with NEMA ICS 1. Mark each device terminal to which a connection is made 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, provide additional wire and cable designations for identification of remote (external) circuits for the Government's wire designations. Prints of shop drawings submitted for approval will be so marked and returned for addition of the designations to the terminal strips and tracings, along with any rearrangement of points required.

[2.3.5 Space Heaters

****

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

Provide space heaters where indicated on the drawings. Control the heaters using an adjustable 10 to 35 degrees C 50 to 95 degrees F thermostat, magnetic contactor, and a molded-case circuit breaker [and a 480-120 volt single-phase transformer]. Provide the space heaters with 250-watt, 240 volt strip elements operated at 120 volts and [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 are open type, electrically-held, rated 30 amperes, 2-pole, with 120-volt ac coils.

]2.4 COMPONENTS

****
NOTES: This guide 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. 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, specify the less expensive Type B construction, which does not include master section terminal boards. If the procurement includes both types of control centers, clearly indicate the type of each control center.

Coordinate NEMA class and construction type with "Wiring" paragraph.
****

Design each motor control center for operation on [480] [_____]-volts ac, 3-phase, 60-Hz system, and the ensure that equipment conforms to all the applicable requirements of NEMA ICS 1, NEMA ICS 2, NEMA ICS 4, NEMA ICS 6, UL 845 and NFPA 70. List and label vertical sections and individual units 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. Provide NEMA Class [I] [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.

2.4.1 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. 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, 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. Avoid reduced voltage starting where possible.

This guide 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, 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.
****

Providefull-voltage, non-reversing combination motor controller units containing [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]. Show the ratings of [motor circuit protectors,] [circuit breakers,] contactors, motor controllers and other devices on the drawings. Ensure all combination motor controller units 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, mount them on the unit compartment door. Door-mounted components cannot interfere with access within the compartments. [Molded case circuit breakers for use in combination starters meet the requirements of paragraph MOLDED CASE CIRCUIT BREAKERS.] [Motor circuit protectors are only part of the combination starters as required by NFPA 70 and conform to all requirements of paragraph MOLDED CASE CIRCUIT BREAKERS, except that trip units have provisions for locking the selected trip setting.]

2.4.1.1 Magnetic Contactors

Provide magnetic contactors of the NEMA sizes as indicated on the drawings. The rating, performance and service characteristics conforms to the requirements of NEMA ICS 2 for contactors with continuous current ratings for the duty indicated. Rate motor control contactors for full-voltage starting (Class A controllers). Provide contactors suitable for at least 200,000 complete operations under rated load without more than routine maintenance. Minimize the interruption arc and flame by suitable arc chutes or other means so that no damage is done to other portions of the device. If provided, ensure the arc chutes are easily removable without removing or dismantling other parts. All current-carrying contact surfaces are silver-surfaced or of other approved material. Ensure the contactor operates without chatter or perceptible hum while energized. Provide coils suitable for continuous operation [120-volt ac] [480-volt ac] [125-volt dc] circuits. Provide three-pole alternating-current contactors, except where otherwise noted, and insulated for 600 volts ac, electrically- operated, magnetically-held type. Direct-current contactors are 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.

[2.4.1.2 Reduced Voltage Starters

****
NOTES: Ensure motor loads using reduced voltage starting are able to operate with reduced starting torque.

Use autotransformer starters 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. Coordinate acceleration requirements to specific motor.

Delete this paragraph when reduced voltage starters are not required.

****

Provide an integrated unit with microprocessor logic board and door mounted digital display and keypad. Comply with UL 508.

[Rate autotransformers for medium duty and have taps according to NEMA ICS 2. For thermal over load protection, ensure the autotransformer has normally closed thermostat wired in series with the normally closed thermal overload contact of the starter. Initial connection is to the [65] [_____] percent tap.] [Solid State soft-start starters are three phase SCR controlled for stepless reduced voltage starting of induction motors. Ensure controllers are equipped with a minimum of two SCRs per phase.] Current transformers provide feedback signal to regulate torque during start up and to prevent overload conditions while motor is running. Provide the starter with a starting current of 300 percent of full load amps for thirty seconds, bypass/isolation contactor, and three phase thermal overload relay.

Provide manufacturer's standard front accessible keypad and digital display for programming the controller parameters, functions, and features. Include the following functions:

a. Adjusting motor full-load amperes, as a percentage of the controller's rating.

b. Adjusting current limitation on starting, as a percentage of the motor full-load current rating.

c. Adjusting linear acceleration and deceleration ramps, in seconds.

d. Setting initial torque, as a percentage of the nominal motor torque.

e. Adjusting torque limit, as a percentage of the nominal motor torque.

f. Adjusting maximum start time, in seconds.

g. Adjusting voltage boost, as a percentage of the nominal supply voltage.

h. Selecting stopping mode and adjusting parameters.

i. Selecting motor thermal-overload protection class between 5 and 30.

j. Activating and deactivating protection modes.

k. Selecting or activating communications modes.

Provide manufacturer's standard front accessible digital display for showing motor, controller, and fault status. Include the following displays at a minimum:

a. Controller Condition: Ready, starting, running, stopping.

b. Motor Condition: Amperes, voltage, power factor, power, and thermal state.

c. Fault Conditions: Controller thermal fault, motor overload alarm and trip, motor underload, overcurrent, shorted SCRs, line or phase loss, phase reversal, and line frequency over or under normal.

Provide integral controller diagnostics and protection to include:

a. Microprocessor-based thermal protection system for monitoring SCR and motor thermal characteristics, and providing controller overtemperature and motor overload alarm and trip; settings selectable via the keypad.

b. Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and underload conditions; and line frequency excursions to over- or under-normal. Provide protection using [input isolation contactor that opens when the controller diagnostics detect a faulted solid state component, or when the motor is stopped.][shunt trip that opens the disconnecting means when the controller diagnostics detect a faulted solid state component.]

****

NOTE: The following features are typical options for most manufacturers. Coordinate with project requirements for inclusion in specification.

****

Provide the additional optional features:

a. Analog output for field-selectable assignment of motor operating characteristics; 4- to 20-mA dc.

b. [Two] additional field-assignable Form C contacts for alarm outputs.

c. Full-voltage/BYPASS selector switch. Ensure power contacts are totally enclosed, double break, made of silver-cadmium oxide, and assembled to allow inspection and replacement without disturbing line or load wiring.

]2.4.1.3 Variable Frequency Controllers

Provide variable frequency controllers meeting the requirements of Section 26 29 23 ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS.

2.4.1.4 Auxiliary Contacts

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

2.4.1.5 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, provide each controller with [solid state][bi-metallic [non-]ambient compensated] NEMA Class [20][_____] thermal overload relays including external manual reset.[

Provide bi-metallic relays with interchangeable heaters, calibrated for 1.0 and 1.15 service factor motors, electrically isolated normally open and normally closed contacts, visual trip indication, test trip feature operable without removing components or the motor starter. Overload to have (+/-) 24 percent adjustability, single-phase sensitivity, isolated alarm contact, and [manual] [or] [automatic reset].][

Provide solid state, ambient insensitive, self-powered relays with adjustable full-load amperage, phase unbalance, phase loss protection, built-in thermal memory, isolated auxiliary contacts and [manual][automatic] reset.]

[2.4.1.6 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, provide an individual control transformer on the load side of the unit disconnect. Rate the control transformers 480-120 volts and conform to the requirements for control transformers in UL 506. Verify control transformers have adequate volt-ampere capacity for the control functions indicated. Install transformers [without] [with] [Class J] primary fuses. Except as otherwise indicated on the drawings, provide each control transformer with a fuse in one secondary lead and have the other secondary lead grounded.

][2.4.1.7 Voltage Fault Protection

****

NOTE: Evaluate voltage fault protection requirements and delete this paragraph when not required.

****

Where shown, provide starters with protection against [voltage faults,] [phase unbalance,] [phase loss,] [phase reversal,] [undervoltage] [and overvoltage]. Upon sensing one of these faults, the protector de-energizes the starter. The protector uses a combination of voltage and phase-angle sensing to detect phase loss even when regenerated voltages are present. Connect the protector to the load side of the motor circuit disconnect. The protector has 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 has a repeatability of +1 percent of set point, maximum, and a dead band of 2 percent maximum. Provide a protector with a green indicator to show normal status and red indicator to show tripped status. Ensure indicators are visible through the compartment door, when LED's are used cover the protector with a clear unbreakable cover, when lamps are used provide nameplates and group with other indicating lights.

]2.4.1.8 Control Circuit Disconnects

****
NOTE: The requirement for disconnect of the control circuit is required by, NFPA 70 Article 430 Part VI section 430.75. Generally, manufacturers do not disconnect control voltage except when racking out the starter unit which is not NFPA compliantas currently written. This paragraph is a specialized requirement to avoida potential safety hazard and ensure compliance. 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. Investigate specific project requirements for interlocking and safety, and modify this paragraph accordingly.
****

Arrange motor control circuits to ensure that all sources of supply power are disconnected when the disconnecting means is in the open position in accordance with NFPA 70. Where separate disconnecting means are provided, locate disconnects immediately adjacent to each other.

[2.4.2 Panelboards for Motor Control Centers

Provide panelboards meeting the requirements of Section 26 24 16.00 40 PANELBOARDS.

]2.4.3 Distribution Transformers

Provide [drawout,] dry type, two-winding, 60 hertz transformers for power and lighting loads with voltage and kVA ratings as indicated on the drawings. Ensure the transformers conform to the requirements for general-purpose transformers in IEEE C57.12.01 and NEMA ST 20. Protect each transformer on the primary side with a molded case circuit breaker as indicated on the drawings.

For 15 kVA and greater provide transformers with 220 degrees C428 degrees F insulation system for temperature rise not exceeding 115 degrees C239 degrees F under full-rated load in maximum ambient of 40 degrees C104 degrees F and capable of carrying continuously 115 percent of nameplate kVA without exceeding insulation rating.

[2.4.4 Ground Detector Indicator

****
NOTE: Evaluate ground detectors requirements. Delete paragraph when not required.
****

Provide ground-detector indicator (GDI) rated for 120-volts. Ensure GDI has three lamps, one per phase, three 480-120 volt transformers connected delta-wye, an adjustable loading resistor for balancing capacitive charging current, and a push-to test-switch. GDI provides 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, ensure all lamps glow at partial brightness, giving long lamp life, the push-to test switch does not affect the brightness of any lamp. When a single ground-fault occurs on any phase, and the lamp that corresponds to the faulted phase is dark and the other two lamps glow at full brightness. The push-to-test switch causes all lamps to return to partial brightness, showing the GDI is functioning properly.

]2.4.5 Wiring for Motor Control Centers

Provide wiring meeting the requirements of paragraph WIRING. Provide heavy-duty type terminals for terminating all power cables entering the control centers.

2.4.5.1 Contractor's Wiring

Form wiring into groups, suitably bound together, properly supported and run straight horizontally or vertically with no splices in the wiring. The manufacturer's standard pressure-type wire terminations for connections to internal devices is acceptable. Add terminal blocks for wiring to devices having leads instead of terminals. Use ring tongue indented terminals on all wires terminated on control terminal blocks for external or interpanel connections and at shipping splits. Provide stud terminals with contact nuts and either locking nuts or lockwashers.

2.4.5.2 External Connections

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

Power and control cables 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 after award of contract.]

2.4.5.3 Terminal Blocks

In no case, the terminals provided for circuit breakers or contactors accommodate less than the number or size of conductors shown on the drawings. Give special attention 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.

[2.4.6 Control Power

****
NOTE: Delete when individual control transformers are specified are provided.
****

[Provide 120-volt control power to individual starters from an external

source as indicated.

][Provide control power for motor control centers using an integrated control power transformer. Mount control power transformers for several starter units in a separate compartment and connect its primary windings to the main bus through a molded case circuit breaker of suitable rating. Rate the control power transformers 480-120 volts and conform to the requirements for control power transformers in UL 506. Provide control power transformers with adequate volt-ampere capacity for the control functions indicated and an additional 10 percent capacity. Install control power transformers without primary fuses. Except as otherwise indicated, provide each unit compartment a fuse for control power in one secondary lead and have the other secondary lead grounded.]

]2.4.7 Accessories and Control Devices

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

Provide control accessories, and are suitable for mounting on the front of, or inside, the control centers as indicated on the drawings. Control accessories to meet the applicable requirements of NEMA ICS 2. Mount relays and other equipment so that mechanical vibration does not cause false operation.

2.4.7.1 Control Stations

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

2.4.7.2 LED Indicating Lights

Furnish red and green LED's where shown on the drawings, indicating contact "open" and "closed" position. The LED's are accessible and replaceable from the front of the control center through a finished opening in the compartment door. The LED assemblies are the heavy duty oiltight, watertight, and dusttight type.

2.4.7.3 Control Relays

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

2.4.7.4 Timing Relays

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

drawings.

2.4.7.5 Alternators

Alternators 120-volt, 60 Hz, single-phase, open type, suitable for mounting inside of control center as indicated. Alternators to 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 repeats the first cycle. The duration of a cycle is determined by an [external device] [adjustable time delay]. Provide contacts with a minimum contact rating designation of A600 or N600, as required, in accordance with NEMA ICS 2.

2.4.7.6 Elapsed-Time Meters

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

2.4.8 Feeder Tap Units

Provide feeder tap units as indicated on the drawings. Feeder tap units include externally operable molded-case circuit breakers in combination motor-control unit enclosures for the protection of non-motor loads or remotely located magnetic motor-controllers. Contain not more than two molded-case circuit breakers in feeder tap units.

2.4.9 Metering Section

Provide metering section with instruments as indicated on the drawings.

2.4.9.1 Instrument Transformers

Comply with the interference requirements listed below, measured in accordance with IEEE C63.2 and IEEE C63.4 for instrument transformers.

2.4.9.1.1 Current Transformers (CT)

Provide current transformers conforming to IEEE C57.13 for installation in metal-clad switchgear. Use standard multi-ratio 5A secondary transformers. Ensure CTs are coordinated to the rating of the associated switchgear, relays, and instruments and CTs for relaying have a thermal rating factor of 2.0.

Provide [wound] [bushing] [bar] [window] type transformers.

Provide transformers that have [single] [double] secondary winding.

Provide transformers that are complete with secondary short-circuiting device.

Provide indoor dry type construction for window type transformers with secondary current ratings as indicated with specified burden, frequency, and accuracy.

2.4.9.1.2 Potential Transformers

Provide potential transformers conforming to IEEE C57.13 for installation in metal-clad switchgear. Use standard 120-volt secondary, drawout type, 60 Hz transformers with voltage ratings and ratios coordinated to the ratings of the associated switchgear, relays, and instruments. Ensure potential transformers are equipped with two current limiting fuses in the primary sized as recommended by the potential transformer manufacturer.

Provide transformers with [single] [tapped] [double] secondary.

Provide burden, frequency, and accuracy as required.

Provide indoor dry type two-winding construction for disconnecting potential transformers with integral fuse mountings and current-limiting fuses with primary and secondary voltage ratings as required.

[2.4.10 Power-Factor-Correction Capacitors

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

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

Provide three-phase, delta-connected capacitors for power factor improvement rated [_____] volts, 60 Hz. [Capacitors have KVAR capacity as shown on the drawings][The capacitor KVAR capacity is 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 cannot 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, mount the capacitors in an adjacent compartment, or otherwise mount separately and connect to the motor at the motor terminal box. [For reduced voltage starters, separately switch the capacitors with a time-delayed contactor rated according to NEMA ICS 2 for capacitor switching.]

][2.4.11 Space for Mounting PLC's

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

Provide space for mounting of Programmable Logic Controllers (PLC's) as indicated on the drawings.

]2.5 TESTS, INSPECTIONS, AND VERIFICATIONS

Submit, within a minimum of [14] [_____] days prior to the proposed date of tests, [six] [_____] copies of manufacturer's routine factory test procedures and production line tests for all motor control centers.

Each item of equipment supplied under this contract is 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 is witnessed by the Contracting Officer unless waived in writing, and no equipment shipped until it has been approved for shipment by the Contracting Officer. 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. The factory test equipment and the test methods used conforms to the applicable NEMA Standards, and is subject to the approval of the Contracting Officer. Reports of all witnessed tests are signed by witnessing representatives of the Contractor and Contracting Officer. Bear the cost of performing all tests and include in the prices bid in the schedule for equipment.

2.5.1 Motor Control Centers Tests

2.5.1.1 Dielectric Tests

Completely assemble the motor control center and perform dielectric tests in accordance with NEMA ICS 1.

2.5.1.2 Operational Tests

Check 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. These checks are made at rated voltage with power supplies to the main buses. Check all magnetic contactors for proper operation with power at 90 percent of rated voltage.

2.5.1.3 Short Circuit Tests

If the unit is not UL labeled for the specified short circuit, design tests may be submitted 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.

2.5.1.4 Test Results

Submit [six] [_____] complete reproducible copies of the factory inspection results and [six] [_____] 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. Contractor's and Contracting Officer's Representatives to sign and date report.

[Provide Motor Control Center Certification signed by official authorized to certify on behalf of the manufacturer, attesting that the motor control center meets the specified requirements. Ensure the statement is dated after the award of this contract, stating the Contractors name and address, name of the project and location, and list the specific requirements which are being certified.

]PART 3 EXECUTION

****

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

3.1 INSTALLATION

Complete assembly is electrically and mechanically connected and assembled from coordinated subassemblies shipped in complete sections from the manufacturer. Align, level and secure the installation to the supporting construction in accordance with the manufacturer's recommendations.

3.2 FIELD TESTING

****
NOTE: If the specified system is identified as critical, configured, or mission essential, use Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS to establish predictive and acceptance testing criteria, above and beyond that listed below.
****

Perform PT&I tests and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

****
NOTE: Select site tests for motor-control centers from the following paragraphs to suit the project requirements.
****

3.2.1 Acceptance Tests

Perform all applicable inspections and electrical tests, including optional tests, in accordance with NETA ATS.

Engage a factory-authorized service representative to perform startup services. Verify complete system operation including all hardware, software and communication devices. Start units to confirm proper motor rotation and unit operation. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment. Perform final equipment adjustments:

a. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload relay pickup and trip ranges.

b. Adjust overload relay [heaters] [settings for power factor correction capacitors connected to the load side of the overload relays].

c. Adjust the trip settings of motor circuit protectors and thermal-magnetic circuit breakers with adjustable.

d. Set field-adjustable switches and program microprocessors for required start and stop sequences in reduced-voltage, solid state controllers.

Final acceptance depends upon the satisfactory performance of the motor-control centers under test. Do not energize the motor-control center until recorded test data have been approved by the Contracting

Officer. Provide final test reports.

3.3 CLOSEOUT ACTIVITIES

Submit manufacturer's instructions for the motor control units and protective devices including special provisions required to install equipment components and system packages. Detail within special notices hazards and safety precautions.

Provide the warranty to the Contracting Officer.

-- End of Section --