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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2025
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SECTION 26 28 00.00 10

MOTOR CONTROL CENTERS, SWITCHBOARDS AND PANELBOARDS
08/22

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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).
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PART 1 GENERAL

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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

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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	[_____]

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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

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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.

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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	(2024) Unified Inch Screw Threads (UN, UNR, and UNJ 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 A780/A780M	(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM B187/B187M	(2020) Standard Specification for Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar and Shapes
ASTM B317/B317M	(2023) Standard Specification for Aluminum-Alloy Extruded Bar, Rod, Tube, Pipe, Structural Profiles, and Profiles for Electrical Purposes (Bus Conductor)
ASTM D877	(2002; R 2007) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D923	(2007) Standard Practice for Sampling Electrical Insulating Liquids
ASTM D924	(2008) Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids
ASTM D971	(2020) Standard Test Method for Interfacial Tension of Insulating Liquids Against Water by the Ring Method
ASTM D974	(2014; E 2016) Standard Test Method for

	Acid and Base Number by Color-Indicator Titration
ASTM D1500	(2012; R 2017) Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)
ASTM D1524	(2015; R 2022) Standard Test Method for Visual Examination of Used Electrical Insulating Liquids in the Field
ASTM D1533	(2012) Standard Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2023) National Electrical Safety Code
IEEE C37.04	(2018; Erta 2019; Corr 2021) Ratings and Requirements for AC High-Voltage Circuit Breakers with Rated Maximum Voltage Above 1000 V Corrigendum 1
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2025) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C12.4	(1984; R 2011) Registers - Mechanical Demand
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 PB 1	(2011) Panelboards
NEMA PB 2	(2011) Deadfront Distribution Switchboards

NEMA ST 20	(2014) Dry-Type Transformers for General Applications
NEMA/ANSI C12.10	(2011; R 2021) Physical Aspects of Watthour Meters - Safety Standard
NEMA/ANSI C12.11	(2024) 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	(2023; ERTA 1 2024; TIA 24-1; TIA 25-2) National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

DOD 8510.01	(2022) Risk Management Framework (RMF) for DoD Systems
DODI 8500.01	(2014) Cybersecurity

UL SOLUTIONS (UL)

UL 44	(2018; Reprint May 2021) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 50	(2024) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 67	(2018; Reprint Aug 2023) UL Standard for Safety Panelboards
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 489	(2025) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 508	(2018; Reprint Jul 2021) UL Standard for Safety Industrial Control Equipment
UL 845	(2021; Reprint Feb 2025) UL Standard for Safety Motor Control Centers
UL 891	(2019; Reprint Mar 2025) UL Standard for Safety Switchboards
UL 1063	(2017; Reprint Jun 2022) UL Standard for Safety Machine-Tool Wires and Cables

1.3 SUBMITTALS

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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 and Air Force 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.

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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. Submittals not having a "G" or "S" classification are 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

Required Settings

Request For Settings

SD-06 Test Reports

Factory Tests

Acceptance Checks And Tests; G, [_____]

SD-07 Certificates

Motor Control Centers

1.4 DELIVERY, STORAGE, AND HANDLING

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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.

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Submit 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. 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 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. Properly match mark each shipping section to facilitate reassembly, and provide 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 or otherwise 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. [Sections of equipment crated for shipment must be of such size, including crates, that they will pass through a [_____] by [_____] -meter -foot hatch opening and a [_____] by [_____] -meter -foot wall opening.] Carefully package and clearly mark all spare parts and accessories.

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

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

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Furnish spare parts as specified below. All spare parts must be of the same material and workmanship, must meet the same requirements, and must 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
1 for each type and rating	Circuit Breaker
1 for each type and rating	Motor Circuit Protector

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. Provide high quality materials, 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 must 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."

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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. Provide equipment meeting 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

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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.
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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, submit details of and reasons for departures for approval 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. Fasten the nameplates to the panels in proper positions with anodized round-head screws. Lettering must be minimum 13 mm 1/2 inch high. Provide nameplate designations in accordance with lists on the drawings, and as a minimum provide nameplates 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

Furnish all bolts, studs, machine screws, nuts, and tapped holes in accordance with ASME B1.1. Provide sizes and threads of all conduit and fittings, tubing and fittings, and connecting equipment in accordance with ASME B1.20.2MASME B1.20.1. Provide ferrous fasteners that have rust-resistant finish and equip all bolts and screws 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 must meet the above requirements.

2.4 MOLDED CASE CIRCUIT BREAKERS

Provide molded case circuit breakers conforming to the applicable requirements of UL 489 and UL 489. Provide circuit breakers that are manually-operated, that are the quick-make, quick-break, common trip type, and that are of the automatic-trip type unless otherwise specified or indicated on the drawings. Operate all poles of each breaker simultaneously by means of a common handle. Provide operating handles

that clearly indicate whether the breakers are in "On," "Off," or "Tripped" position and have provisions for padlocking in the "Off" position. Provide personnel safety line terminal shields for each breaker. Furnish circuit breakers that are products of only one manufacturer, and are 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 that are suitable for [125] [_____] volts dc and 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.

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Except as otherwise noted, provide combination thermal and instantaneous magnetic or solid state trip units for the circuit breakers, of frame sizes and the trip unit ratings as shown on the drawings. 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 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. Provide interchangeable breaker trip units and instantaneous magnetic trip units that are adjustable on frame sizes larger than 150 amperes. Set nonadjustable instantaneous magnetic trip units at approximately 10 times the continuous current ratings of the circuit breakers. [Solid state trip units, where indicated, must 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

Furnish circuit breakers for 480-volt or 277/480-volt ac circuits that are rated 600 volts ac, andthat 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 rated less than 120/240 or 240 volts ac are not permitted, and must 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 must be two-pole rated 125/250

or 250 volts dc, and must have an UL listed minimum interrupting capacity of [5,000] [10,000] [_____] amperes dc.

2.5 WIRING

Provide control wire consisting of stranded tinned copper switchboard wire with 600-volt flame-retardant insulation Type SIS meeting UL 44 or Type MTW meeting UL 1063, and passing the VW-1 flame tests included in those standards. Provide hinge wire consisting of Class K stranding. Current transformer secondary leads smaller than No. 10 AWG is not permitted. The minimum size of control wire is be No. 14 AWG. Furnish power wiring for 480-volt circuits and below that is the same type as control wiring and a minimum size of 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.

2.6 CONTROL SWITCHES

2.6.1 General

All control switches must be of the rotary switchboard type with handles on the front and the operating contact mechanisms on the rear of the panels. Provide each switch with ample contact stages to perform the functions of the control system and provide with at least two spare contacts. Provide self-aligning contacts that operate with a wiping action. Provide a positive means of maintaining high pressure on closed contacts. Compression springs or pivotal joints must not carry current. All control switches must be suitable for operation on 600-volt AC or 250-volt DC circuits. All such switches must be capable of satisfactorily withstanding a life test of at least 10,000 operations with rated current flowing in the switch contacts. Provide switches capable of continuously carrying 20 amperes without exceeding a temperature rise of 30 degrees C. The single-break inductive load interrupting rating of switches must not be less than 1.5 amperes for 125 volts DC or 10 amperes for 115 volts AC.

2.6.2 Switch Features

a. Provide control and instrument switches that are suitable for the intended use and that have the features shown on the schematic diagrams and switch development drawings. Provide switches that have handles as shown or approved and are black in color unless otherwise specified.

b. Control switches for electrically-operated circuit breakers must be 3-position momentary-contact type with spring return to neutral position, and must have modern-black, heavy duty pistol grip handles. Provide circuit breaker control switches that have mechanical operation indicators to show the last manual operation of the switches and slip contacts.

c. Provide control switches for instrument and meter transfer switches and for selector switches that are the maintained contact type with the required number of positions and that have round notched or knurled handles. Connect ammeter and voltmeter switches to read all three phase ammeter switches. Do not open the secondary circuits of the current transformer at any time.

d. Provide each control switch with an escutcheon clearly marked to show each operating position. Engrave the switch identifications on the

escutcheon plates or on separate nameplates. The escutcheon and nameplate markings are subject to approval.

2.7 TERMINAL BLOCKS

Furnish control circuit terminal blocks for control wiring that are molded or fabricated type with barriers, rated not less than 600 volts. Provide terminals that are removable binding, fillister or washer head screw type, or of the stud type with contact and locking nuts. The terminals must be no less than No. 10 in size and have 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 and provide no less than four (4) spare terminals or 10 percent, whichever is greater, 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.

2.7.1 Types of Terminal Blocks

2.7.1.1 Short-Circuiting Type

Furnish short-circuiting type terminal blocks for all current transformer secondary leads and have provision for shorting together all leads from each current transformer without first opening any circuit. Provide terminal blocks meeting the requirements of paragraph CONTROL CIRCUIT TERMINAL BLOCKS above.

2.7.1.2 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 terminals that are either the stud type with contact nuts and locking nuts or 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, provide screws with hexagonal heads. Conducting parts between connected terminals must have adequate contact surface and cross-section to operate without overheating. Place the circuit designation or wire number on or near the terminal in permanent contrasting color for each connected terminal.

2.7.2 Marking Strips

Provide white or other light-colored plastic marking strips, fastened by screws to each terminal block, for wire designations. Make wire numbers with permanent ink. Use reversible marking strips to permit marking both sides, or furnish two marking strips with each block. Marking strips must accommodate the two sets of wire numbers. For each device to which a connection is made, assign a device designation in accordance with NEMA ICS 1 and 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. Show the general arrangement and overall dimensions of the motor control centers, switchboards, and panelboards. 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.

2.8 SPACE HEATERS

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

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Provide space heaters where indicated on the drawings and control 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]. Provide space heaters that are 250-watt, 240 volt strip elements operated at 120 volts and are [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]. Furnish contactors that are open type, electrically-held, rated 30 amperes, 2-pole, with 120-volt ac coils.

2.9 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.

****

Design each motor control center for operation on 480-volts ac, 3-phase, 60-Hz system, and equipment conforming to all the applicable requirements of NEMA ICS 1, NEMA ICS 2, NEMA ICS 4and NEMA ICS 6. 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.

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

b. Furnish motor control center that is 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 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 must 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 must 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.

2.9.1 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.

****

Provide motor control center consisting 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. Provide vertical section that is 510 mm 20 inches deep and buses, control wiring, control transformers, small power transformers, terminal blocks, line terminals, cable supports, and clamps that are accessible from the front. Provide NEMA Type [1 gasketed] [12] [3R] enclosure. Fabricate the control centers from smooth select steel sheets shaped and reinforced to form rigid free-standing structures. Metal thickness for enclosures less than specified in NEMA ICS 6 are not acceptable. Fabricate and bolt vertical edges of sections exposed to view so that the joints will not pass a 1.6 mm 1/16 inch gage. Design each structure for the addition of future sections required. Isolate individual compartments from adjacent compartments.

2.9.1.1 Unit Compartments

Each operating unit must contain equipment as shown on the drawings, mounted in an individual cell. The unit assembly, except main circuit breakers, panelboards and auxiliary control devices, must be drawout type removed from the front, without rear access or disturbing other units in the control center assembly. Provide drawout type unit assemblies that have positive guide rail system to ensure alignment of connection to vertical bus. Provide units that are mechanically interlocked with the door to prevent removal while in the energized position. Each removable unit must have 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.

2.9.1.2 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. Provide interlocked door fastenings to prevent opening when the equipment is energized. Provide external operating handle that clearly indicates whether the equipment is in an "ON", "OFF" or "TRIPPED" position.

2.9.1.3 Horizontal Wireways

[Structure must have a minimum 300 mm 12 inches high wireway at the top and a 150 mm 6 inches minimum wireway at the bottom.] [Structure must have a minimum 150 mm 6 inches high wireway at the top and a 300 mm 12 inches minimum wireway at the bottom.] Run both horizontal wireways 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.

2.9.1.4 Vertical Wireways

Provide vertical wireways in all vertical sections accepting multiple plug-in components. Connect vertical wireways with horizontal wireways at the top and bottom and are a minimum 100 mm 4 inches wide. Provide barriers in sections containing both ac and dc vertical buses. Provide doors on each vertical wireway. The exposed surface of any door must not deviate more than 1.5 mm 1/16 inch from a true plane.

2.9.1.5 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.

****

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 and a maximum channel depth of 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.

2.9.1.6 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 must comply with NFPA 101 for means of egress and lighting.

****

The motor control center must be non-walk in NEMA Type 3R rainproof enclosure as shown on the drawings. Provide outside enclosure consisting of smooth select steel sheets on a structural steel frame. Provide full-length single or double doors with top and bottom bolts and a center latch operated by means of a keyed handle. Provide steel sheets and doors that are no less than 3.5 mm No. 10 gage thick and doors that 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. Provide ventilating openings and 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. The outside edges of the control center base must permit easy sealing at the concrete surface with mastic compound. Furnish a 200-watt outdoor lighting fixture with globe and guard to light

the front of the assembly. Provide watertight lighting connections. 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. Provide "ac" rated, 15 amperes, 120/277 volts exterior manual switch. Provide two duplex receptacle units within the outer weatherproof enclosure. Wire the lighting fixture and receptacles to the 120-volt ac panelboard located in the control center, and run external wiring in rigid galvanized steel conduit.

2.9.1.7 Shutters

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

[2.9.1.8 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].

]2.9.2 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.
****

Furnish buses that are copper [or aluminum] and furnish [all bolted splices and connections between buses and for extensions or taps for equipment that are tin or silver-plated] [that are tin or silver-plated throughout]. Provide copper [or aluminum] bars and shapes for bus conductors comforming 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 Celsius maximum temperature rise in accordance with UL 845 requirements. Bus must have 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.

2.9.2.1 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.]

2.9.2.2 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.

2.9.2.3 Ground Bus

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

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

[2.9.2.4 Neutral Bus

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

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

]2.9.3 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 will 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 will 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.

****

Furnish 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]. Provide ratings of [motor circuit protectors,] air circuit breakers, contactors, motor controllers and other devices as shown on the drawings. All combination motor controller units must 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 must not interfere with access within the compartments. [Provide molded case circuit breakers for use in combination starters meeting 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 provide trip units that have provision for locking the selected trip setting.]

2.9.3.1 Magnetic Contactors

Provide magnetic contactors of the NEMA sizes indicated on the drawings.

Conform to the requirements of NEMA ICS 2 for contactors with continuous current ratings for the duty indicated. Provide contactors for motor control that are rated for full-voltage starting (Class A controllers). Provide contactors that are 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 will be done to other portions of the device. The arc chutes, if provided, must be easily removable without removing or dismantling other parts. The contacts must be easily removable. All current-carrying contact surfaces must be silver-surfaced or of other approved material to prevent the formation of high resistance oxides. Operate the contactor without chatter or perceptible hum while energized. Provide coils that are suitable for continuous operation [120-volt ac] [480-volt ac] [125-volt dc] circuits. Provide alternating-current contactors that are three-pole, except where otherwise noted, and insulated for 600 volts ac and of the electrically- operated, magnetically-held type. Provide direct-current contactors that 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.

[2.9.3.2 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.

****

[Provide autotransformers rated for medium duty and have taps according to NEMA ICS 2. For thermal over load protection, the autotransformer must have normally closed thermostat wired in series with the normally closed thermal overload contact of the starter. Make initial connection to the [65] [_____] percent tap.] [Provide solid state soft-start starters consisting of three phase SCR controlled for stepless reduced voltage starting of induction motors.] Current transformers must provide feedback signal to regulate torque during start up and to prevent overload conditions while motor is running. Furnish starter with starting current of 300 percent of full load amps for thirty seconds, bypass/isolation contactor, and three phase thermal overload relay.

]2.9.3.3 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.

2.9.3.4 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, provide three NEMA Class 20 thermal or solid state overload relays with external manual reset for each controller. 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.

[2.9.3.5 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, provide individual control transformer on the line side of the unit disconnect. Provide control transformers rated 480-120 volts and conforming to the requirements for control transformers in UL 508. Provide control transformers that have adequate volt-ampere capacity for the control functions indicated. Install transformers [without] [with] primary fuses. [Provide Class J primary fuses.] Except as otherwise indicated on the drawings, provide each control transformer with a fuse in one secondary lead and ground the other secondary lead.

][2.9.3.6 Voltage Fault Protection

****

NOTE: Voltage fault protection requirements should be evaluated and this paragraph deleted 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 must de-energize the starter. Use 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. Provide 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 must have repeatability of +1 percent of set point, maximum, and a dead band of 2 percent maximum. Provide green indicator to show normal status and red indicator to show tripped status. Indicators will be visible through the compartment door. Cover protector with a clear unbreakable cover when LED's are used. Provide nameplates when lamps are used and group with other indicating lights.

]2.9.4 Molded Case Circuit Breakers in Unit Compartments

Provide molded case circuit breakers for installation in unit compartments meeting the requirements of paragraph MOLDED CASE CIRCUIT BREAKERS above.

2.9.5 Panelboards for Motor Control Centers

Provide panelboards meeting the requirements of paragraph PANELBOARDS.

2.9.6 Distribution Transformers

Furnish dry type transformers for power and lighting loads with voltage and kVA ratings as indicated on the drawings. Provide transformers conforming to the requirements for general-purpose transformers in NEMA ST 20. Protect each transformer on the primary side with a molded case circuit breaker as indicated on the drawings. [Provide drawout type transformers.]

[2.9.7 Ground Detector Indicator

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

Provide ground-detector indicator (GDI) rated 120-volts; has 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. 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 must glow at partial brightness, giving long lamp life, the push-to test switch must not affect the brightness of any lamp. When a single ground-fault occurs on any phase, the lamp that corresponds to the faulted phase must be dark and the other two lamps must glow at full brightness. The push-to-test switch must cause all lamps to return to partial brightness, showing the GDI is functioning properly.

]2.9.8 Wiring for Motor Control Centers

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

2.9.8.1 Contractor's Wiring

Form Contractor's wiring into groups, suitably bound together, properly support and run straight horizontally or vertically. There must be no splices in the wiring. The manufacturer's standard pressure-type wire terminations for connections to internal devices will be 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 contact nuts and either locking nuts or lockwashers for all stud terminals.

2.9.8.2 External Connections

****
NOTE: For NEMA 3R enclosures power cables must 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.]

2.9.8.3 Terminal Blocks

Furnish terminal blocks meeting the requirements of paragraph TERMINAL BLOCKS above. In no case must 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.

[2.9.9 Control Transformers

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

Mount control 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. Provide control transformers that are rated 480-120 volts and conforming to the requirements for control transformers in UL 508. Provide control transformers with adequate volt-ampere capacity for the control functions indicated and an additional 10 percent capacity. Install transformers without primary fuses. Except as otherwise indicated on the drawings, each unit compartment must provide a fuse for control power in one secondary lead and must have the other secondary lead grounded. Equip the unit disconnect with a normally open contact to isolate the control circuit from the source when the controller disconnect is open.

]2.9.10 Accessories and Control Devices

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

Provide control accessories that are suitable for mounting on the front of, or inside, the control centers as indicated on the drawings. Provide control accessories meeting the applicable requirements of NEMA ICS 2. Mount relays and other equipment so that mechanical vibration will not

cause false operation.

2.9.10.1 Control Stations

Provide push-button stations and selector switches in conformance to NEMA ICS 2, of the heavy-duty, oil-tight type, rated 600 volts ac, and with 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.]

2.9.10.2 LED Indicating Lights

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

2.9.10.3 Control Relays

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

2.9.10.4 Timing Relays

Provide pneumatic type timers that are 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.

2.9.10.5 Alternators

Alternators 120-volt, 60 Hz, single-phase, open type, suitable for mounting inside of control center as indicated. Alternators must 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]. Provide contacts with a minimum contact rating designation of A600 or N600, as required, in accordance with NEMA ICS 2.

2.9.10.6 Elapsed-Time Meters

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

2.9.11 Feeder Tap Units

Provide feeder tap units as indicated on the drawings.

2.9.12 Metering Section

Provide metering section with instruments as indicated on the drawings.

2.9.12.1 Instrument Transformers

Use transformers for metering meeting the requirements of NEMA/ANSI C12.11 and IEEE C57.13. Protect voltage transformers with removable primary and secondary fuses. Install fuses in each ungrounded lead and locate adjacent to the transformers in an easily accessible place. If cable connections to current transformer primary are required, furnish terminals of an approved solderless type and proper size. If current transformers are connected to buses, furnish proper connections, complete with bolts, nuts, washers and other accessories.

2.9.12.2 Ammeters

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

2.9.12.3 Voltmeters

Provide switchboard type voltmeter 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. Provide meters that are long scale 175 mm 6.8 inches, semiflush rectangular, indicating type mounted at eye level.

2.9.12.4 Watthour Meters

Furnish watthour meters conforming to ANSI C12.1 and NEMA/ANSI C12.10, except numbered terminal wiring sequence and case size may be the manufacturer's standard. Provide watthour meters of the drawout switchboard type having a 15-minute, cumulative form, demand register meeting NEMA C12.4 and provide with no less than two and one-half stators. [Provide watthour demand meters that have factory installed electronic pulse initiators meeting the requirements of ANSI C12.1.]

2.9.12.5 Switches

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

[2.9.13 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 will 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 must be rated [_____] volts, 60 Hz. [Capacitors must have KVAR capacity as shown on the drawings] [Select the capacitor KVAR capacity 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 must 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, 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.]

][2.9.14 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.

]2.10 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 must be in accordance with NEMA PB 2.
****

Provide dead-front switchboards conforming to NEMA PB 2 and label under UL 891. Provide 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. Provide switchboards that are fully rated for a short-circuit current of [14,000] [22,000] [65,000] [_____] symmetrical amperes RMS AC.

2.10.1 Enclosure

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

Provide NEMA type [2] [3R] switchboard enclosure, built with selected smooth sheet steel panels of no less than 1.9 mm No. 14 gage. Exposed panels on the front and ends must have bent angle or channel edges with all corner seams welded and ground smooth. Do not drill or weld the front outside surfaces for the purpose of attaching wires or mounting devices if such holes or fastenings will be visible from the front. Make the front panels in sections flanged on four sides and attach to the framework by screws and arrange for ready removal for inspection or maintenance. [Provide rear access to the bus and device connections.] Provide ventilating openings as required and preferably of the grille type. Provide all ventilating openings with corrosion-resistant insect-proof screens on the inside. [Provide each switchboard with a channel iron base at front, rear, and sides, with exposed ends covered by welded steel plates. Provide grout holes. Bolt the switchboard sections to the base.] [Mount switchboards as shown on the drawings and furnish mounting materials as indicated.] Treat all interior and exterior steel parts to inhibit corrosion and paint as specified in paragraph PAINTING.

2.10.2 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.
****

Provide buses that are copper [or aluminum] and [all bolted splices and connections between buses and for extensions or taps for equipment] that are tin or silver-plated [throughout]. Provide copper [or aluminum] bars and shapes for bus conductors conforming 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. Horizontal and vertical power buses have minimum current ratings as shown on the drawings. Insulate the buses for no less than 600 volts. Braze, pressure-weld or bolt shop splices and tap connections. Bolt all splices for field assembly. Mount the buses on insulating supports of wet process porcelain, glass polyester, or suitable molded material, and brace to withstand no less than [14,000] [22,000] [65,000] [_____] symmetrical amperes ac.

2.10.3 Grounding Bus

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

Mount a copper [or aluminum] ground bus, rated no less than 300 amps, extending the entire length of the assembled structure, near the bottom of enclosure. Provide a full clamp-type solderless copper or copper alloy

lug for No. 2/0 AWG stranded copper cable at each end of the bus for connection to the station grounding system.

2.10.4 Components

Equip each switchboard 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. Stationary mount the circuit breakers individually, as shown on the drawings, that are operable and removable from the front. Where shown on the drawings, enclose circuit breakers in individual compartments. [Provide the group-mounted circuit breakers complete with bus work in an integrated assembly on the switchboard and conform to the applicable requirements of paragraph PANELBOARDS.]

2.11 PANELBOARDS

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

Provide panelboards consisting 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. Provide UL 67 labeled panelboards. "Loadcenter" type panels are not acceptable. Design panelboards for installation in surface-mounted or flush-mounted cabinets accessible from the front only, as shown on the drawings. Provide panelboards that are fully rated for a short-circuit current of [14,000] [22,000] [_____] symmetrical amperes RMS ac.

2.11.1 Enclosure

Furnish enclosures meeting the requirements of UL 50. Fabricate all cabinets from sheet steel of no less than 3.5 mm No 10 gage if flush-mounted or mounted outdoors, and no less than 2.7 mm No 12 gage if surface-mounted indoors, with full seam-welded box ends. Hot-dip galvanize cabinets mounted outdoors or flush-mounted after fabrication. Paint cabinets in accordance with paragraph PAINTING. Provide outdoor cabinets 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.] Form-flange edges of cabinets or fit with structural shapes welded or riveted to the sheet steel, for supporting the panelboard front. Fabricate all cabinets so that no part of any surface on the finished cabinet deviates from a true plane by more than 3 mm 1/8 inch. Provide holes 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. Mount flush doors on hinges that expose only the hinge roll to view when the door is closed. Fit each door with a combined catch and lock, except provide doors over 600 mm 24 inches long with a three-point latch having a knob with a T-handle, and a cylinder lock. Provide two keys with each lock, and key all locks alike. Provide finished-head cap screws for mounting the panelboard fronts on the cabinets. Provide enclosure nameplates in accordance with paragraph NAMEPLATES. Provide directory holders, containing a neatly typed or printed directory under a transparent cover, on the inside of panelboard doors.

2.11.2 Buses

****

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.

****

Provide dead-front type panelboards with buses and circuit breakers mounted on a plate or base for installation as a unit in a cabinet. Provide buses that are copper [or aluminum] [and are tin or silver-plated throughout]. Provide copper [or aluminum] bars and shapes for bus conductors conforming to the applicable requirements of ASTM B187/B187M[, and ASTM B317/B317M]. Provide sizes of buses and the details of panelboard construction meeting or exceeding the requirements of NEMA PB 1. Make suitable provisions for mounting the bus within panelboards and adjusting their positions in the cabinets. Provide terminal lugs required to accommodate the conductor sizes shown on the drawing for all branch circuits larger than No. 10 AWG. Provide a grounding bus with a lug suitable for 1/0 AWG wire for each panelboard.

2.11.3 Components

Equip each branch circuit, and the main buses where so specified or shown on the drawings, with molded-case circuit breakers having overcurrent trip ratings as shown on the drawings. Provide circuit breakers designed for bolted connection to buses in a panelboard assembly, and meeting the requirements of paragraph MOLDED CASE CIRCUIT BREAKERS. Circuit breakers of the same frame size and rating must be interchangeable. [Furnish bell alarm contacts as indicated on the drawings and wire to terminal blocks mounted in the cabinet. Furnish terminal blocks conforming to requirements of paragraph TERMINAL BLOCKS.]

2.12 FACTORY TESTS

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

a. Submit 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. Use factory test equipment and the test methods conforming to the applicable NEMA Standards, and are subject to the approval of the Contracting Officer. Submit complete reproducible copies of the factory inspection results and 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 must be signed and dated by the Contractor's and Contracting Officer's Representatives. Reports of all witnessed tests must be signed by witnessing representatives of the Contractor and Contracting Officer. The Contractor is responsible for the cost of performing all tests and include in the prices bid in the schedule for equipment.

2.12.1 Motor Control Centers Tests

2.12.1.1 Dielectric Tests

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

2.12.1.2 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. Make these checks rated voltage with power supplies to the main buses. Also check all magnetic contactors for proper operation with power at 90 percent of rated voltage.

2.12.1.3 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.

2.12.2 Switchboards Tests

2.12.2.1 Production Tests

Completely assemble each switchboard and give applicable production tests for assembled switchboard as specified in NEMA PB 2.

2.12.2.2 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.

2.12.3 Panelboards Tests

Assemble each panelboard with cabinet and front to the extent necessary to check the fit and provisions for installing all parts in the field. Give each panelboard a dielectric test in accordance with NEMA PB 1. Operate all circuit breakers to check mechanical adjustments. Check all doors and locks for door clearances and fits and the performance of lock and latches.

2.13 PAINTING

Clean interior and exterior steel surfaces of equipment enclosures thoroughly and then apply a rust-inhibitive phosphatizing or equivalent

treatment prior to painting. Exterior surfaces must be free from holes, seams, dents, weld marks, loose scale or other imperfections. Apply no less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice to exterior surfaces. Prime exterior, filld where necessary, and give no less than two coats baked enamel with semigloss finish. Equipment located indoors must be ANSI Light Gray, [and equipment located outdoors must be ANSI [Light Grey] [Dark Gray].] Perform all touch-up work with manufacturer's coatings as supplied under paragraph SPARE PARTS.

PART 3 EXECUTION

3.1 INSTALLATION

Conform to IEEE C2, NFPA 70, and to the requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

****
NOTE: Include the grounding section below for installations involving a Motor Control Centers installed in an exterior application. If the MCC is installed adjacent to a pad-mounted distribution transformer, then coordinate the grounding requirements between the applicable specifications.
****

[3.2 GROUNDING

****
NOTE: Where rock or other soil conditions prevent obtaining a specified ground value, specify other methods of grounding. Where it is impractical to obtain the indicated ground resistance values, make every effort to obtain ground resistance values as near as possible to the indicated values.

Select 25 ohms resistance unless the installation requires a lower resistance to ground.
****

NFPA 70 and IEEE C2, except that grounds and grounding systems with a resistance to solid earth ground not exceeding [25][_____] ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of the ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Equipment Grounding

Provide bare copper cable not smaller than No. 4/0 AWG not less than 610 mm 24 inches below grade connecting to the indicated ground rods. When work in addition to that indicated or specified is directed to obtain the specified ground resistance, the provision of the contract covering "Changes" applies.

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Install exothermic welds and compression connectors as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.2.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

]3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect equipment furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.3.1 Motor Control Centers

NEMA ICS 1.

NEMA ICS 2.

3.3.2 Switchboards

NEMA PB 1.

3.3.3 Panelboards

NEMA PB 2.

3.3.4 Field Applied Painting

Where field painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.3.5 Galvanizing Repair

Repair damage to galvanized coatings using ASTM A780/A780M, zinc rich paint, for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces that repair paint has been applied to.

3.3.6 Field Fabricated Nameplate Mounting

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.4 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

****

NOTE: Mounting slab connections may have to be given in detail depending on the requirements for the seismic zone in which the equipment is located. Include construction requirements for concrete slab only if slab is not detailed in drawings.

****

3.4.1 Exterior Location

Mount Motor Control Centers on concrete slab as follows:

a. Unless otherwise indicated, provide the slab with dimensions at least 200 mm 8 inches thick, reinforced with a 150 by 150 mm 6 by 6 inch No. 6 mesh placed uniformly 100 mm 4 inches from the top of the slab.

b. Place slab on a 150 mm 6 inch thick, well-compacted gravel base.

c. Install slab such that the top of the concrete slab is approximately 100 mm 4 inches above the finished grade.

d. Provide edges above grade with 15 mm 1/2 inch chamfer.

e. Provide slab of adequate size to project at least 200 mm [8] [_____] inches beyond the equipment.

f. Provide conduit turnups and cable entrance space required by the equipment to be mounted.

g. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant.

h. Cut off and bush conduits 75 mm 3 inches above slab surface.

i. Provide concrete work as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.4.2 Interior Location

Mount Motor Control Centers on concrete slab as follows:

a. Unless otherwise indicated, provide the slab with dimensions at least 100 mm 4 inches thick.

b. Install slab such that the top of the concrete slab is approximately 100 mm 4 inches above the finished grade.

c. Provide edges above grade with 15 mm 1/2 inch chamfer.

d. Provide slab of adequate size to project at least 200 mm [8] [_____] inches beyond the equipment.

e. Provide conduit turnups and cable entrance space required by the equipment to be mounted.

f. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant.

g. Cut off and bush conduits 75 mm 3 inches above slab surface.

h. Provide concrete work as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.5 FIELD QUALITY CONTROL

****

NOTE: Select "Request for Settings" below if protective device settings will be government furnished. Select "Required Settings" below if protective device settings are furnished by the Designer of Record. Coordinate with the person developing the Division 1 Sections and ensure that Division 1 Sections identify the person responsible for providing the final protective device settings for design/build versus design/bid/build projects. Do not rely on the manufacturer's default settings.

****

[Submit request for settings of breakers to the Contracting Officer after approval of Motor Control Center and at least 30 days in advance of their requirement.

][Submit Required Settings of breakers to the Contracting Officer after approval of the Motor Control Center and at least 30 days in advance of their requirement.

]3.5.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and Section 26 08 00 APPARATUS INSPECTION AND TESTING.

****

NOTE: Select the options below that apply to the specified equipment.

****

3.5.1.1 Motor Control Center

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Compare equipment nameplate data with drawings and specifications.

3. Inspect anchorage, alignment, grounding, and required area clearances.

4. Verify the unit is clean and all shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.

5. Verify that fuse and circuit breaker sizes and types correspond to drawings and coordination study as well as to the circuit breaker address for microprocessor-communication packages.

6. Verify that current and voltage transformer ratios correspond to drawings.

7. Verify that wiring connections are tight and that wiring is secure to prevent damage during routine operation of moving parts.

8. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or

performing thermographic survey.

9. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

10. Confirm correct application of manufacturer's recommended lubricants.

11. Inspect insulators for evidence of physical damage or contaminated surfaces.

12. Verify correct barrier and shutter installation[and operation].

13. Exercise all active components.

14. Inspect all mechanical indicating devices for correct operation.

15. Verify that filters are in place and vents are clear.

16. Test operation, alignment, and penetration of instrument transformer withdrawal disconnects.

17. Inspect control power transformers.

b. Electrical Tests

1. Perform insulation-resistance tests on each bus section.

2. Perform dielectric withstand voltage tests.

3. Perform insulation-resistance test on control wiring; Do not perform this test on wiring connected to solid-state components.

4. Perform control wiring performance test.

5. Perform primary current injection tests on the entire current circuit in each section of assembly.

[6. Perform phasing check on double-ended motor control center to ensure correct bus phasing from each source.]

7. Verify operation of motor control center heaters.

3.5.1.2 Circuit Breakers - Low Voltage - Power

a. Visual and Mechanical Inspection

1. Compare nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify that all maintenance devices are available for servicing and operating the breaker.

5. Inspect arc chutes.

6. Inspect moving and stationary contacts for condition, wear, and alignment.

7. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.

8. Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism.

9. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

10. Verify cell fit and element alignment.

11. Verify racking mechanism.

12. Confirm correct application of manufacturer's recommended lubricants.

b. Electrical Tests

1. Perform contact-resistance tests on each breaker.

2. Perform insulation-resistance tests.

3. Adjust Breaker(s) for final settings in accordance with Government provided settings.

4. Determine long-time minimum pickup current by primary current injection.

5. Determine long-time delay by primary current injection.

****
NOTE: Coordinate each option with each breaker type.
****

6. Determine short-time pickup and delay by primary current injection.

7. Determine ground-fault pickup and delay by primary current injection.

8. Determine instantaneous pickup value by primary current injection.

9. Activate auxiliary protective devices, such as ground-fault or undervoltage relays, to ensure operation of shunt trip devices; Check the operation of electrically-operated breakers in their cubicle.

10. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and antipump function.

11. Verify operation of charging mechanism.

3.5.1.3 Current Transformers

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Verify correct connection.

4. Verify that adequate clearances exist between primary and secondary circuit.

5. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

6. Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

1. Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

2. Perform insulation-resistance tests.

3. Perform polarity tests.

4. Perform ratio-verification tests.

3.5.1.4 Metering and Instrumentation

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Verify tightness of electrical connections.

b. Electrical Tests

1. Determine accuracy of meters at 25, 50, 75, and 100 percent of full scale.

2. Calibrate watthour meters according to manufacturer's published data.

3. Verify all instrument multipliers.

4. Electrically confirm that current transformer and voltage transformer secondary circuits are intact.

3.5.1.5 Grounding System

a. Visual and Mechanical Inspection

1. Inspect ground system for compliance with contract plans and

specifications.

b. Electrical Tests

1. IEEE 81. Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground resistance tester in accordance with manufacturer's instructions to test each ground or group of grounds. Use an instrument equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

2. Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.5.1.6 Switches, Air, Low-Voltage

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, grounding, and required clearances.

4. Verify the unit is clean.

5. Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.

6. Verify that fuse sizes and types are in accordance with drawings, short-circuit studies, and coordination study.

7. Verify that each fuse has adequate mechanical support and contact integrity.

8. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

9. Verify operation and sequencing of interlocking systems.

10. Verify correct phase barrier installation.

11. Verify correct operation of all indicating and control devices.

12. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a

low-resistance ohmmeter, in accordance with Section 7.5.1.1.A.8.1 of NETA ATS.

2. Measure contact resistance across each switchblade and fuseholder.

3. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.1 of NETA ATS.

4. Measure fuse resistance.

5. Verify cubicle space heater operation.

6. Perform ground fault test in accordance with Section 7.14 of NETA ATS.

7. Perform tests on other protective devices in accordance with Section 7.9 of NETA ATS.

3.5.1.7 Switches, Air, Medium-Voltage, Metal-Enclosed

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, grounding, and required clearances.

4. Verify the unit is clean.

5. Verify correct blade alignment, blade penetration, travel stops, arc interrupter operation, and mechanical operation.

6. Verify that fuse sizes and types are in accordance with drawings, short-circuit study, and coordination study.

7. Verify that expulsion-limiting devices are in place on all fuses having expulsion-type elements.

8. Verify that each fuseholder has adequate mechanical support and contact integrity.

9. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

10. Verify operation and sequencing of interlocking systems.

11. Verify correct phase barrier installation.

12. Verify correct operation of all indicating and control devices.

13. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.5.1.2.A.9.1 of NETA ATS.

2. Measure contact resistance across each switchblade assembly and fuseholder.

3. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.1 of NETA ATS.

4. Perform a dielectric withstand voltage test on each pole with switch closed. Test each pole-to-ground with all other poles grounded. Test voltage will be in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.2 of NETA ATS.

5. Measure fuse resistance.

6. Verify cubicle space heater operation.

7. Perform online partial-discharge survey in accordance with Section 11 of NETA ATS.

3.5.1.8 Circuit Breakers

3.5.1.8.1 Circuit Breakers, Air, Insulated-Case/Molded-Case

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage and alignment.

4. Verify the unit is clean.

5. Operate the circuit breaker to insure smooth operation.

6. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

7. Inspect operating mechanism, contacts, and arc chutes in unsealed nits.

8. Perform adjustments for final protective device settings in accordance with the coordination study.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.6.1.1.A.6.1 of

NETA ATS.

2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.1 of NETA ATS.

3. Perform a contact/pole-resistance test.

4. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components, follow manufacturer's recommendation.

5. Determine long-time pickup and delay by primary current injection.

6. Determine short-time pickup and delay by primary current injection.

7. Determine ground-fault pickup and time delay by primary current injection.

8. Determine instantaneous pickup by primary current injection.

9. Test functions of the trip unit by means of secondary injection.

10. Perform minimum pickup voltage tests on shunt trip and close coils in accordance withmanufacturer's published data.

11. Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, anti-pump function, and trip unit battery condition. Reset all trip logs and indicators.

12. Verify operation of charging mechanism.

3.5.1.8.2 Circuit Breakers, Low-Voltage Power

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify that all maintenance devices are available for servicing and operating the breaker.

5. Verify the unit is clean.

6. Verify the arc chutes are intact.

7. Inspect moving and stationary contacts for condition and alignment.

8. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.

9. Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism in accordance with manufacturer's published data.

10. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey

11. Verify cell fit and element alignment.

12. Verify racking mechanism operation.

13. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

14. Perform adjustments for final protective device settings in accordance with coordination study provided by end user.

15. Record as-found and as-left operation counter readings.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.6.1.2.A.10.1 of NETA ATS.

2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Test voltage will be in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.1 of NETA ATS.

3. Perform a contact/pole-resistance test.

4. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components, follow manufacturer's recommendation.

5. Determine long-time pickup and delay by primary current injection.

6. Determine short-time pickup and delay by primary current injection.

7. Determine ground-fault pickup and delay by primary current injection.

8. Determine instantaneous pickup value by primary current injection.

9. Test functions of the trip unit by means of secondary injection.

10. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.20 of NETA ATS.

11. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, antipump function, and trip unit battery

condition. Reset all trip logs and indicators.

12. Verify operation of charging mechanism.

3.5.1.8.3 Circuit Breakers, Air, Medium-Voltage

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify that all maintenance devices are available for servicing and operating the breaker.

5. Verify the unit is clean.

6. Verify the arc chutes are intact.

7. Inspect moving and stationary contacts for condition and alignment.

8. If recommended by manufacturer, slow close/open breaker and check for binding, friction, contact alignment, and penetration. Verify that contact sequence is in accordance with manufacturer's published data. In the absence of manufacturer's data, use IEEE C37.04.

9. Perform all mechanical operation tests on the operating mechanism in accordance with manufacturer's published data.

10. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey

11. Verify cell fit and element alignment.

12. Verify racking mechanism operation.

13. Inspect puffer operation.

14. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

15. Perform contact-timing test.

16. Perform mechanism-motion analysis.

17. Perform trip/close coil current signature analysis.

18. Record as-found and as-left operation-counter readings.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. See Section 7.6.1.3.A.10.1 of NETA ATS.

2. Perform insulation-resistance tests for one minute on each pole,

phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.1 of NETA ATS.

3. Perform a contact/pole-resistance test.

4. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be on minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow manufacturer's recommendation.

5. With breaker in the test position, make the following tests:

(a) Trip and close breaker with the control switch.

(b) Trip breaker by operating each of its protective relays.

(c) Verify mechanism charge, trip-free, and antipump functions.

6. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.20 of NETA ATS.

7. Perform power-factor or dissipation-factor tests with breaker in both the open and closed positions.

8. Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap. In the absence of a power-factor/ capacitance tap, perform hot-collar tests. These tests will be in accordance with the test equipment manufacturer's published data.

9. Perform a dielectric withstand voltage test on each phase with the circuit breaker closed and the poles not under test grounded. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.19 of NETA ATS.

10. Measure blowout coil circuit resistance.

11. Verify operation of heaters.

12. Test instrument transformers in accordance with Section 7.10 of NETA ATS.

3.5.1.8.4 Circuit Breakers, Oil, Medium- and High-Voltage

a. Visual and Mechanical Inspection

1. Visual and Mechanical Inspection

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, grounding, and required clearances.

4. Verify that all maintenance devices such as special tools and gauges specified by the manufacturer are available for servicing and

operating the breaker.

5. Verify correct oil level in all tanks and bushings.

6. Verify that breather vents are clear.

7. Verify the unit is clean.

8. Inspect hydraulic system and air compressor in accordance with manufacturer's published data.

9. Test alarms and pressure-limit switches for pneumatic and hydraulic operators as recommended by the manufacturer.

10. Perform mechanical operation tests on the operating mechanism in accordance with manufacturer's published data.

11. While performing internal inspection:

(a) Remove oil. Lower tanks or remove manhole covers as necessary. Inspect bottom of tank for broken parts and debris.

(b) Inspect lift rod and toggle assemblies, contacts, interrupters, bumpers, dashpots, bushing current transformers, tank liners, and gaskets.

(c) Verify that contact sequence is in accordance with manufacturer's published data. In the absence of manufacturer's data, use IEEE C37.04.

(d) Fill tank(s) with filtered oil.

12. Inspect bolted electrical connections for high resistance using one or more of the following methods:

(e) Use of low-resistance ohmmeter in accordance with Section 7.6.2.B.1 of NETA ATS.

(f) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.12 of NETA ATS.

(g) Perform thermographic survey in accordance with Section 9 of NETA ATS.

14. Verify racking mechanism operation.

15. Perform contact-timing test.

16. Perform mechanism-motion analysis.

17. Perform trip/close coil current signature analysis.

18. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

19. Record as-found and as-left operation counter readings.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.6.2.A.12.1 of NETA ATS.

2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit-breaker closed, and across each open pole. Test voltage will be in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.1 of NETA ATS.

3. Perform a static contact/pole resistance test.

4. Perform a dynamic contact/pole resistance test.

5. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components, follow manufacturer's recommendation.

6. Remove a sample of insulating liquid in accordance with ASTM D923. Sample will be tested in accordance with the referenced standard.

(a) Dielectric breakdown voltage: ASTM D877

(b) Color: ASTM D1500

(c) Power factor: ASTM D924

(d) Interfacial tension: ASTM D971

(e) Visual condition: ASTM D1524

(f) Neutralization number (acidity): ASTM D974

(g) Water content: ASTM D1533

7. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.20 of NETA ATS.

8. Verify correct operation of any auxiliary features such as electrical close and trip operation, trip-free, antipump function.

9. Trip circuit breaker by operation of each protective device. Reset all trip logs and indicators.

10. Perform power-factor or dissipation-factor tests on each pole with breaker open and each phase with breaker closed. Determine tank loss index.

11. Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap. In the absence of a power-factor/capacitance tap, perform hot-collar tests. These tests will be in accordance with the test equipment manufacturer's published data.

12. Perform a dielectric withstand voltage test in accordance with manufacturer’s published data.

13. Verify operation of heaters.

14. Test instrument transformers in accordance with Section 7.10 of NETA ATS.

3.5.1.8.5 Circuit Breakers, Vacuum, Medium-Voltage

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify that all maintenance devices such as special tools and gauges specified by the manufacturer are available for servicing and operating the breaker.

5. Verify the unit is clean.

6. Perform all mechanical operation tests on the operating mechanism in accordance with manufacturer’s published data.

7. Measure critical distances such as contact gap as recommended by manufacturer.

8. Inspect bolted electrical connections for high resistance using one or more of the following methods:

(a) Use of low-resistance ohmmeter in accordance with Section 7.6.3.B.1 of NETA ATS.

(b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.12 of NETA ATS.

(c) Perform thermographic survey in accordance with Section 9 of NETA ATS.

9. Verify cell fit and element alignment.

10. Verify racking mechanism operation.

11. Verify appropriate lubrication on moving, current-carrying parts and on moving and sliding surfaces.

12. Perform contact-timing test.

13. Perform trip/close coil current signature analysis.

14. Perform mechanism motion analysis.

15. Record as-found and as-left operation counter readings.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.6.3.A.8.1 of NETA ATS.

2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Test voltage will be in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.1 of NETA ATS.

3. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components, follow manufacturer's recommendation.

4. Perform a contact/pole-resistance test.

5. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.20 of NETA ATS.

6. Verify correct operation of any auxiliary features such as electrical close and trip operation, trip-free, and antipump function.

7. Trip circuit breaker by operation of each protective device. Reset all trip logs and indicators.

8. Perform power-factor or dissipation-factor tests on each pole with the breaker open and each phase with the breaker closed.

9. Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap. In the absence of a power-factor/capacitance tap, perform hot-collar tests. These tests will be in accordance with the test equipment manufacturer's published data.

10. Perform magnetron atmospheric condition (MAC) test on each vacuum interrupter.

11. Perform vacuum bottle integrity (dielectric withstand voltage) test across each vacuum bottle with the breaker in the open position in strict accordance with manufacturer's published data.

12. Perform a dielectric withstand voltage test in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.19 of NETA ATS.

13. Verify operation of heaters.

14. Test instrument transformers in accordance with Section 7.10 of NETA ATS.

3.5.1.8.6 Circuit Breakers, SF6

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify that all maintenance devices such as special tools and gauges specified by the manufacturer are available for servicing and operating the breaker.

5. Verify the unit is clean.

6. When provisions are made for sampling, remove a sample of SF6 gas and test in accordance with Table 100.13 of NETA ATS. Do not break seal or distort “sealed-for-life” interrupters.

7. Inspect operating mechanism and/or hydraulic or pneumatic system and SF6 gas-insulated system in accordance with manufacturer’s published data.

8. Test for SF6 gas leaks in accordance with manufacturer’s published data.

9. Verify correct operation of alarms and pressure-limit switches for pneumatic, hydraulic, and SF6 gas pressure in accordance with manufacturer’s published data.

10. If recommended by manufacturer, slow close/open breaker and check for binding, friction, contact alignment, and penetration. Verify that contact sequence is in accordance with manufacturer’s published data. In the absence of manufacturer’s data, refer to IEEE C37.04.

11. Perform all mechanical operation tests on the operating mechanism in accordance with the manufacturer’s published data.

12. Inspect all bolted electrical connections for high resistance using one or more of the following methods:

(a) Use of a low-resistance ohmmeter in accordance with Section 7.6.4.B.1 of NETA ATS.

(b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.12 of NETA ATS.

(c) Perform a thermographic survey in accordance with Section 9 of NETA ATS.

13. Verify the appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

14. Perform contact-timing test.

15. Perform trip/close coil signature analysis.

16. Perform mechanism motion analysis.

17. Record as-found and as-left operation counter readings.

b. Electrical Tests

1. Perform resistance measurements through all bolted connections with a low-resistance ohmmeter in accordance with Section 7.6.4.A.12.1 of NETA ATS.

2. Perform insulation-resistance tests in accordance with Table 100.1 of NETA ATS from each pole-to-ground with breaker closed and across open poles at each phase. For single-tank breakers, perform insulation resistance tests in accordance with Table 100.1 from pole-to-pole.

3. Perform a contact/pole-resistance test.

4. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components or for control devices that cannot tolerate the voltage, follow manufacturer’s recommendation.

5. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer’s published data.

6. Verify correct operation of any auxiliary features such as electrical close and trip operation, trip-free, and antipump function. Reset all trip logs and indicators.

7. Trip circuit breaker by operation of each protective device.

8. Perform power-factor or dissipation-factor tests on each pole with the breaker open and on each phase with the breaker closed.

9. Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap. In the absence of a power-factor/capacitance tap, perform hot-collar tests. These tests will be in accordance with the test equipment manufacturer’s published data.

10. Perform a dielectric withstand voltage test in accordance with manufacturer’s publisheddata.

11. Verify operation of heaters.

12. Test instrument transformers in accordance with Section 7.10 from NETA ATS.

3.5.1.9 Motor Control, Motor Starters, Low-Voltage

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify the unit is clean.

5. Inspect contactors.

(a) Verify mechanical operation.

(b) Verify contact gap, wipe, alignment, and pressure are in accordance with manufacturer's published data.

6. Motor-Running Protection

(c) Verify overload element rating/motor protection settings are correct for application.

(d) If motor-running protection is provided by fuses, verify correct fuse rating.

7. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

8. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.16.1.1.A.7.1 from NETA ATS.

2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with starter closed, and across each open pole. Test voltage will be in accordance with manufacturer's published data or Table 100.1 from NETA ATS.

3. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components, follow manufacturer's recommendation.

4. Test motor protection devices in accordance with manufacturer's published data. In the absence of manufacturer's data, use Section 7.9 from NETA ATS.

5. Test circuit breakers in accordance with Section 7.6.1.1 from NETA ATS.

6. Perform operational al tests by initiating control devices.

3.5.1.10 Motor Control, Motor Starters, Medium-Voltage

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify the unit is clean.

5. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

6. Test electrical and mechanical interlock systems for correct operation and sequencing.

7. Verify correct barrier and shutter installation and operation.

8. Exercise active components and confirm correct operation of indicating devices.

9. Inspect contactors.

(a) Verify mechanical operation.

(b) Verify contact gap, wipe, alignment, and pressure are in accordance with manufacturer's published data.

10. Verify overload protection rating is correct for its application. Set adjustable or programmable devices according to the protective device coordination study.

11. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.16.1.2.A.5.1 from NETA ATS.

2. Perform insulation-resistance tests on contactor(s) for one minute, phase-to-ground and phase-to-phase with the contactor closed, and across each open contact. Test voltage will be in accordance with manufacturer's published data, or Table 100.1 from NETA ATS.

3. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components, follow manufacturer's recommendation.

4. Perform magnetron atmospheric condition (MAC) test on each vacuum interrupter.

5. Perform a dielectric withstand voltage test in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.9 from NETA ATS.

6. Perform vacuum bottle integrity test (dielectric withstand voltage) across each vacuum bottle with the contacts in the open position in strict accordance with manufacturer's published data.

7. Perform contact resistance tests.

8. Measure blowout coil circuit resistance.

9. Measure resistance of power fuses.

10. Energize contactor using an auxiliary source. Adjust armature to minimize operating vibration.

11. Test control power transformers in accordance with Section 7.1.B.8 from NETA ATS.

12. Test starting transformers, in accordance with Section 7.2.1 from NETA ATS.

13. Test starting reactors, in accordance with 7.20.3 from NETA ATS.

14. Test motor protection devices in accordance with manufacturer's published data. In the absence of manufacturer's data, test in accordance with Section 7.9 from NETA ATS.

15. Standard Commissioning Specifications for Electrical Power Equipment & Systems.

16. Verify operation of cubicle space heater.

17. Test instrument transformers in accordance with Section 7.10 from NETA ATS.

18. Test metering devices in accordance with Section 7.11 from NETA ATS.

3.5.1.11 Cybersecurity Installation Certification

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NOTE: Coordinate equipment certification withGovernment's cybersecurity requirements and interpretations. Select this option if the motor control includes remote control or remote access capability.

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Furnish a certification that control systems are installed in accordance with DODI 8500.01, DOD 8510.01, and as required by individual Service Implementation Policy.

3.5.2 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Trip circuit breakers by operation of each protective device. Test each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, provide the Contracting Officer 5 working days advance notice of the dates and times for checks, settings, and tests.

-- End of Section --