UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2022
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DIVISION 26 - ELECTRICAL

SECTION 26 05 70.00 40

HIGH VOLTAGE OVERCURRENT PROTECTIVE DEVICES

05/19

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USACE / NAVFAC / AFCEC / NASA | **UFGS-26 05 70.00 40 (May 2019)**

Preparing Activity: NASA | **Superseding UFGS-26 05 70.00 40 (February 2015)**

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SECTION 26 05 70.00 40

HIGH VOLTAGE OVERCURRENT PROTECTIVE DEVICES
05/19

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NOTE: This guide specification covers the requirements for circuit breakers, fuses, motor controls, and control devices. This section supports Section 33 75 00.00 40 SWITCHGEAR AND PROTECTION DEVICES; accordingly, include it to the extent applicable to project requirements. Show frame and trip ratings, interrupting ratings, and NEMA types and sizes, as well as single-line and schematic diagrams, elevations, and details on drawings.

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

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

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

****

PART 1 GENERAL

1.1 REFERENCES

****

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

and title.

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

References not used in the text are automatically deleted from this section of the project specification when you choose to reconcile references in the publish print process.

****

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering
ANSI C39.1	(1981; R 1992) Requirements for Electrical Analog Indicating Instruments

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M	(2003; R 2021) Standard Specification for Gray Iron Castings
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM D877	(2002; R 2007) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D2472	(2000; R 2014) Standard Specification for Sulphur Hexafluoride
ASTM D3487	(2016; E2017) Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.09	(2018; Errata 2019; Corr 2021) Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
IEEE C37.2	(2008) Standard for Electrical Power

	System Device Function Numbers, Acronyms and Contact Designations
IEEE C37.40	(2003; Errata 2003; R 2009) Service Conditions & Definitions for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, & Accessories
IEEE C37.41	(2016; Corr 2017) Design Tests for High-Voltage (>1000 V) Fuses and Accessories
IEEE C37.42	(2016) Specifications for High-Voltage (> 1000 V) Fuses and Accessories
IEEE C37.46	(2010) Standard for High Voltage Expulsion and Current-Limiting Type Power Class Fuses and Fuse Disconnecting Switches
IEEE C37.47	(2011) Standard for High Voltage Distribution Class Current-Limiting Type Fuses and Fuse Disconnecting Switches
IEEE C37.121	(2012) American National Standard for Switchgear-Unit Substations - Requirements
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers
IEEE C63.2	(2009) Standard for Electromagnetic Noise and Field Strength Instrumentation, 10 Hz to 40 GHz - Specifications
IEEE C63.4	(2014) American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

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

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 60255-149	(2013) Measuring Relays and Protection Equipment

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C78.23	(1995; R 2003) American National Standard

	for Incandescent Lamps - Miscellaneous Types
NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA AB 3	(2013) Molded Case Circuit Breakers and Their Application
NEMA ICS 1	(2000; R 2015) 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 3	(2005; R 2010) Medium-Voltage Controllers Rated 2001 to 7200 V AC
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA SG 2	(1993) Standard for High-Voltage Fuses

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

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

UNDERWRITERS LABORATORIES (UL)

UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 489	(2016; Rev 2019) 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

1.2 ADMINISTRATIVE REQUIREMENTS

[Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to work specified in this section.

]

1.3 SUBMITTALS

****

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

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

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

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

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

****

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

SD-01 Preconstruction Submittals

Sample Warranty[; G[, [____]]]

SD-02 Shop Drawings

Connection Diagrams[; G[, [____]]]

Fabrication Drawings[; G[, [____]]]

SD-03 Product Data

High-Voltage Motor Controllers[; G[, [____]]]

Instrument Transformers[; G[, [____]]]

Current Transformers[; G[, [____]]]

Potential Transformers[; G[, [____]]]

Enclosures[; G[, [____]]]

Circuit Breakers[; G[, [____]]]

Protective Relays[; G[, [____]]]

Indicating Instruments[; G[, [____]]]

Indicating Lights[; G[, [____]]]

Fuses[; G[, [____]]]

SD-06 Test Reports

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

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

SD-07 Certificates

Warranty[; G[, [____]]]

Factory Tests[; G[, [____]]]

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals[; G[, [____]]]

1.4 QUALITY CONTROL

1.4.1 Regulatory Requirements

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

1.4.2 Qualification

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

1.4.3 Predictive Testing and Inspection Technology Requirements

****

NOTE: The Predictive Testing and Inspection (PT&I) tests prescribed in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS are MANDATORY for all [NASA] [_____] assets and systems identified as Critical, Configured, or

Mission Essential. If the system is non-critical, non-configured, and not mission essential, use sound engineering discretion to assess the value of adding these additional test and acceptance requirements. See Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS for additional information regarding cost feasibility of PT&I.

****

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

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

1.4.4 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products that have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Provide products that have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, use items of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.4.1 Material and Equipment Manufacturing Date

Do not use products manufactured more than 3 years prior to date of delivery to site, unless specified otherwise.1.4.5 Shop Drawings

Submit connection diagrams showing the relations and connections of control devices and protective devices by showing the general physical layout of all controls, the interconnection of one system (or portion of system) with another, and internal tubing, wiring, and other devices.

Submit fabrication drawings for control devices and protective devices consisting of fabrication and assembly details to be performed in the factory.

1.5 WARRANTY

Submit manufacturer's sample warranty for review and acceptance to the Contracting Officer.

PART 2 PRODUCTS

2.1 EQUIPMENT

2.1.1 High-Voltage Motor Controllers

Provide motor controllers conforming to NEMA ICS 3, and UL 508. Provide controllers that have thermal overload protection in each phase.

Provide high-voltage motor controllers for the control and protection of squirrel-cage induction motors, wound-rotor induction motors, and synchronous machines rated 2.4 through 13.8 kilovolts, three-phase, that are NEMA ICS 2, Class E2, type as required.

Unless enclosed within a switchgear or unit-substation cubicle, house high-voltage motor controllers in floor-mounted structures of the NEMA type indicated, approximately 2300 millimeter 90 inches high, 750 millimeter 30 inches wide, and 750 millimeter 30 inches deep, with suitable draw-out compartments. Include structural provisions for padlocking the doors.

Subdivide structure into low-voltage control compartment with separate door, high-voltage control compartment with separate door, ac bus compartment, and cable-entrance compartment.

Isolate controller by externally operated draw-out stabs with shutter mechanism which also opens the secondary of the control-power transformer. Provide interlocks to prevent inadvertent operation of the isolating mechanism under load, opening the medium-voltage compartment door without isolating the starter, and closing the line contactor with door open. Include an isolating switch assembly.

For overload protection, include ambient-compensated thermal overload relays and hand reset in all three phases. Utilizing solid state multifunction overload protection is acceptable when approved.

Provide fused type controllers employing current-limiting power fuses of the interrupting rating indicated. Provide fuses with fatigue proof elements that allow the elements to absorb expansions and contractions created by the heating and cooling associated with cycling associated with normal motor starting. Provide single-phase antitrip protection. Provide magnetic air-break line contactors rated not less than 5 kilovolts on starters. Provide control circuit with provisions for external testing of 120-volt control circuit and a minimum of one set of normally open and normally closed auxiliary contacts.

2.1.1.1 Vacuum Contactor

Provide vacuum contactor of the [slide-out] [roll-out] and [latched] [magnetically-held] design, rated [300] [400] [800] [_____] amperes with single-break high-pressure type main contacts with weld-resistant alloy contact faces. Ensure that the vacuum contactor contact wear is easily checked with the use of a "go/no-go" feeler gauge.

Provide built-in test circuitry to permit checking of the starter control and pilot circuit, with the high voltage de-energized and isolated, and the contactor in its normal position or in the drawout position. Ensure the control circuit is capable of being energized through a polarized plug connector from an external 115-volt supply while in the test mode.

2.1.1.2 Starters

****
NOTE: Ensure starter ratings, types, and accessories are coordinated with drawings and included in the following section.
****

Provide starters designed to accommodate motors of the size and type as indicated. Provide [non-reversing] [reversing] starters for [Induction Motor Full-Voltage Start], [Induction Motor Autotransformer Start], [Induction Motor Reactor Start], [Induction Motor Solid State Reduced Voltage Start], [Synchronous Motor Full-Voltage Start - Brush-Type], [Synchronous Motor Full-Voltage Start - Brushless-Type] motors.

Provide starters with interrupting rating with current limiting fuses of [_____]. [When starters are grouped together in a lineup, ensure the entire assembly is suitable for application on a power system having a short circuit-capacity of [_____].]

****
NOTE: Ensure that any additional accessories necessary for the the type of starter specified are included in the list below.
****

Each starter high-voltage compartment includes:

a. Starter isolating switch [with blown fuse indicator].

b. Three [Bolt-in] [Clip-in] Current-limiting power fuses for each starter.

c. [Stab-in] [Bolt-in] contactor assembly.

d. Control circuit transformer with primary current limiting fuses and secondary fusing.

e. Run/Test circuit.

f. Electrical interlocks.

g. Current transformers for use with electronic overload.

[
h. Ground fault current transformer where ground fault protection is indicated.]

[
i. Additional contactor for motor reversing. Ensure both contactors are mechanically and electrically interlocked.]

Each starter low-voltage compartment includes:

a. Motor Protection Relay

b. Control relays

c. Set of control circuit terminal blocks

d. Potential Transformers

e. Isolation switch viewing window to verify switch position

f. Current transformer shorting terminal block

2.1.2 Instrument Transformers

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

Influence		Preferred			Ratio	
Insulation Class, kV	Basic Insulation Level, kV	Nominal System Voltage, kV	Test Voltage for Potential Transformers, kV	Test Voltage for Current Transformers, kV	Voltage Level, Microvolts Dry Type	Oil Filled
0.6	10	.....	.....	0.76	250	250
1.2	30	0.208 0.416 0.832 1.04	0.132 0.264 0.528 0.66	0.76	250	250
2.5	45	2.40	1.52	1.67	250	250
5.0	60	4.16 4.80	2.64 3.04	3.34	250	250
8.7	75	7.20 8.32	4.57 5.28	5.77	250	250
15L or 15H	95-110	12.00 12.47 14.40	7.62 7.92 9.14	9.41	1000	250
25	150	23.00	14.60	15.70	2500	650
34.5	200	34.50	21.90	23.0	....	650
46	250	46.00	29.20	29.30	....	1250
69	350	69.00	43.80	44.00	....	1250
92	450	92.00	58.40	58.40	....	2500
115	550	115.00	73.40	73.40	....	2500
138	650	138.00	88.00	88.00	....	2500

2.1.2.1 Current Transformers (CT)

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

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

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

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

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

2.1.2.2 Potential Transformers

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

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

Provide burden, frequency, and accuracy as required.

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

2.1.3 Enclosures

2.1.3.1 Equipment Enclosures

Provide enclosures for equipment in accordance with NEMA 250 and NEMA ICS 6. Ensure enclosures are completely front accessible. Provide outdoor enclosures equipped with space heaters and thermostats. Obtain control power from an [internal control power transformer] [external source as indicated].

[a. Contain equipment installed inside clean, dry locations in a NEMA Type 1, general-purpose sheet-steel enclosure.

][b. Contain equipment installed in wet locations in NEMA Type 4 watertight, corrosion-resistant sheet-steel enclosure, constructed to prevent entrance of water when tested in accordance with NEMA ICS 6 for Type 4 enclosures.

][c. Contain equipment installed in industrial locations in a NEMA Type 12 industrial use, sheet-steel enclosure constructed to prevent the entrance of dust, lint, fibers, flying's, oil, and coolant seepage.

][d. Contain equipment installed in Class I, Division I, Group A, B, C, and D, hazardous locations in NEMA Type 7 enclosures approved for the specific flammable gas or vapor that is possibly present under normal operating conditions.

][e. Contain equipment installed in Class II, Division I, Group E, F and G, hazardous locations in NEMA Type 9 enclosures approved for use where combustible dust is possibly present under normal operating conditions.

][f. Fabricate sheet-steel enclosures from uncoated commercial quality carbon-steel sheets. Ensure box dimensions and thickness of sheet steel are in accordance with UL 50.

][g. Fabricate steel enclosures from corrosion-resistant, chromium-nickel steel sheet conforming to ASTM A167 Type 300 series with ASM No. 4 general-purpose polished finish. Ensure box dimensions and thickness of sheet steel are in accordance with UL 50.

]2.1.3.2 Control Station Enclosures

Provide control station enclosures for pushbuttons, selector switches, and indicating lights in accordance with the appropriate articles of NEMA ICS 6 and NEMA 250.

[a. Contain control stations installed in indoor, clean, dry locations in NEMA Type 1 general-purpose, sheet-steel enclosures. Contain recessed control stations in standard wall outlet boxes with matching corrosion-resistant steel flush cover plate.

][b. Contain control stations installed in wet locations in NEMA Type 4 watertight, corrosion-resistant sheet-steel enclosures constructed to prevent entrance of water when tested in accordance with NEMA ICS 6 and NEMA 250 for Type 4 enclosures.

][c. Contain control stations installed in wet locations in NEMA Type 4 watertight, cast-iron enclosures constructed to prevent entrance of water when tested in accordance with NEMA ICS 6 and NEMA 250 for Type 4 enclosures.

][d. Contain control stations installed in dry noncombustible dust-laden atmospheres in NEMA Type 12 dusttight, cast-iron enclosures with gaskets or their equivalent to prevent the entrance of dust.

][e. Contain control stations installed in industrial locations in NEMA Type 12 industrial-use, sheet-steel enclosures constructed to prevent the entrance of dust, lint, fibers, filings, oil, and coolant seepage.

][f. Contain control stations installed in industrial locations in NEMA Type 12 industrial-use, cast-iron enclosures constructed to prevent the entrance of dust, lint, fibers, filings, oil, and coolant seepage.

][g. Contain control stations installed in Class I, Division I, Group A, B, C, and D, hazardous locations in NEMA Type 7 enclosures approved for the specific flammable gas or vapor which is possibly present under normal operating conditions.

][h. Contain control stations installed in Class II, Division I, Group E, F and G, hazardous locations in NEMA Type 9 enclosures approved for use where combustible dust is possibly present under normal operating conditions.
]

****
NOTE: Select the material type most suitable to the project requirements and environmental conditions.
****

[Fabricate sheet-steel enclosures from uncoated carbon-steel sheets of

commercial quality. Ensure box dimensions and thickness of sheet steel are in accordance with UL 50.

][Fabricate steel enclosures from corrosion-resistant, chromium-nickel steel sheet conforming to ASTM A167, Type 300 series with ASM No. 4 general-purpose polished finish. Ensure box dimensions and thickness of sheet steel are in accordance with UL 50.

][Provide cast-iron enclosures of gray-iron castings conforming to ASTM A48/A48M, with tensile-strength classification recognized as suitable for this application. Provide cast metal enclosures that are not less than 3 millimeter 1/8 inch thick at reinforcing ribs and door edges and not less than 6 millimeter 1/4 inch thick at tapped holes for conduit.

] Install control stations with the centerline 1700 millimeter 66 inches above the finished floor.

2.1.4 Circuit Breakers

Provide circuit breakers conforming to UL 489 and NEMA AB 3.

2.1.4.1 Air Circuit Breakers

Provide circuit breakers that include a ground-fault system or ground-sensing relays.

2.1.4.1.1 Stored-Energy-Operated Type

For air circuit breakers with stored-energy-operated mechanisms, conform to IEEE C37.121 for metal-clad switchgear rated above [600 volts] [5 kilovolts], [14.4 kilovolts] [grounded] [ungrounded].

Mount metal-clad air circuit breakers on a mobile frame with primary and secondary disconnecting devices, automatic shutters, and mechanical interlocks to allow complete removal of the unit for inspection and maintenance. Provide three-pole, single-throw, electrically operated circuit breakers, with a motor-charged spring, stored-energy mechanism, and electric release coils for tripping and closing operations.

Provide a motor-operated position-changing mechanism that moves the breaker between the test and operating position by means of a levering device. Provide interlocks to prevent the complete withdrawal of the circuit breaker from its compartment when the stored-energy mechanism is in the fully charged position. Design circuit breakers to prevent the release of stored energy unless the mechanism is fully charged.

Provide circuit breakers that have mechanically trip-free mechanisms with direct-current potential trip coils of the voltage indicated, auxiliary switches, latch-checking switches, control relays, and operation counters.

2.1.4.1.2 Solenoid-Operated Type

Conform to IEEE C37.121 for air circuit breakers with solenoid-operated mechanisms and the appropriate articles for metal-clad switchgear rated above [600 volts] [5 kilovolts] [14.4 kilovolts].

Mount metal-clad air circuit breakers on a mobile frame with primary and secondary disconnecting devices, automatic shutters, and mechanical interlocks to allow complete removal of the unit for inspection and

maintenance. Provide three-pole single-throw circuit breakers, with solenoid-operated tripping/closing mechanism designed for operation on a [direct-current station battery power supply] [direct from an emergency ac power system of [_____] voltage].

Rate the mechanism closing coils for [_____] volts and operable at voltages as low as [_____] volts. Rate the mechanism trip coils for [_____] volts and operable at voltages as low as [_____] volts. Provide an operating mechanism for ac control circuits by the manufacturer for [_____] voltage.

Provide circuit breakers with mechanically trip-free mechanisms including auxiliary switches, latch-checking switches, control relays, and operation counters. The use of solid state tripping devices is acceptable.

2.1.4.2 Oil Circuit Breakers

For oil circuit breakers, use control voltage as indicated with a tripping mechanism consisting of a magnet acting as a trigger to release a latch, permitting the breaker to open. Provide a pneumatic operating system with compressors and reservoirs as needed. Integrate tripping and closing control with the breakers.

Provide three phase distribution-voltage breakers with all three interrupters mounted in the same tank. Provide transmission-voltage oil circuit breakers with the phase interrupters mounted in separate tanks.

Equip circuit-breaker bushings with bushing current transformers and standard secondary taps. Provide taps that are terminated outside the tank housing on terminal blocks and identified for short circuiting.

Enclose operating mechanism in a waterproof housing mounted on the breaker framework with heaters to prevent condensation of moisture. Provide a mechanically trip-free breaker mechanism.

Equip each breaker with complete relaying and controls. Provide relaying consisting of instantaneous and overcurrent time-delay relays plus others as indicated and controls consisting of a reclosing relay, control switch, indicating lights, ammeters, and as approved. Install relays and controls in a control cabinet mounted on the breaker housing [solid state type is acceptable] or [install remotely]. Provide an externally operable manual trip device.

Supply each oil circuit breaker with tank-lowering and tank-lifting devices. Provide a tank drain valve and an oil level indicator on each tank where applicable.

Conform to ASTM D3487 for oil used in the oil circuit breakers.

2.1.4.3 Vacuum Circuit Breakers

Provide circuit breakers that include a ground-fault system or ground-sensing relays.

Provide circuit breakers that contain three vacuum interrupters separately mounted in a self-contained, removable self-aligning pole unit. Ensure components are inserted into a vacuum heat chamber and sealed under vacuum. "Pinch tubes" are not acceptable. Ensure proper isolation of the ambient air and the vacuum. Design circuit breakers to prevent rotation

of the contact within the vacuum chamber and the contacts are self-aligning. Ensure contacts do not require adjustments for the life of the vacuum interrupter assembly.

2.1.4.3.1 Stored-Energy-Operated Type

For vacuum circuit breakers with stored-energy-operated mechanisms, conform to IEEE C37.121 for metal-clad switchgear rated above [600 volts] [5 kilovolts], [14.4 kilovolts] [grounded] [ungrounded].

Mount metal-clad vacuum circuit breakers on a mobile frame with primary and secondary disconnecting devices, automatic shutters, and mechanical interlocks to allow complete removal of the unit for inspection and maintenance. Provide three-pole, single-throw, electrically operated circuit breakers, with a motor-charged spring, stored-energy mechanism, and electric release coils for tripping and closing operations.

Provide a motor-operated position-changing mechanism that moves the breaker between the test and operating position by means of a levering device. Provide interlocks to prevent the complete withdrawal of the circuit breaker from its compartment when the stored-energy mechanism is in the fully charged position. Design circuit breakers to prevent the release of stored energy unless the mechanism is fully charged.

Provide circuit breakers that have mechanically trip-free mechanisms with direct-current potential trip coils of the voltage indicated, auxiliary switches, latch-checking switches, control relays, and operation counters.

2.1.4.3.2 Solenoid-Operated Type

Conform to IEEE C37.121 for vacuum circuit breakers with solenoid-operated mechanisms and the appropriate articles for metal-clad switchgear rated above [600 volts] [5 kilovolts] [14.4 kilovolts].

Mount metal-clad vacuum circuit breakers on a mobile frame with primary and secondary disconnecting devices, automatic shutters, and mechanical interlocks to allow complete removal of the unit for inspection and maintenance. Provide three-pole single-throw circuit breakers, with solenoid-operated tripping/closing mechanism designed for operation [on a direct-current station battery power supply][direct from an emergency ac power system of [_____] volts].

Rate the mechanism closing coils for [125][_____] volts and operable at voltages as low as [90][_____] volts. Rate the mechanism trip coils for [125][_____] volts and operable at voltages as low as [70][_____] volts. Provide an operating mechanism for ac control circuits by the manufacturer for [_____] volts.

Provide circuit breakers with mechanically trip-free mechanisms including auxiliary switches, latch-checking switches, control relays, and operation counters. The use of solid state tripping devices is acceptable.

2.1.4.4 SF6 Circuit Breakers

Provide circuit breakers that include a ground-fault system or ground-sensing relays.

Provide circuit breakers that contain three sulfur hexafluoride (SF6) interrupters separately mounted in a self-contained, removable

self-aligning pole unit. Design circuit breakers to prevent rotation of the contact within the vacuum chamber and the contacts are self-aligning. Ensure contacts do not require adjustments for the life of the vacuum interrupter assembly. Ensure SF6 circuit breakers are shipped factory filled with SF6 gas conforming to ASTM D2472.

2.1.4.4.1 Stored-Energy-Operated Type

For SF6 circuit breakers with stored-energy-operated mechanisms, conform to IEEE C37.121 for metal-clad switchgear rated above [600 volts] [5 kilovolts], [14.4 kilovolts] [grounded] [ungrounded].

Mount metal-clad SF6 circuit breakers on a mobile frame with primary and secondary disconnecting devices, automatic shutters, and mechanical interlocks to allow complete removal of the unit for inspection and maintenance. Provide three-pole, single-throw, electrically operated circuit breakers, with a motor-charged spring, stored-energy mechanism, and electric release coils for tripping and closing operations.

Provide a motor-operated position-changing mechanism that moves the breaker between the test and operating position by means of a levering device. Provide interlocks to prevent the complete withdrawal of the circuit breaker from its compartment when the stored-energy mechanism is in the fully charged position. Design circuit breakers to prevent the release of stored energy unless the mechanism is fully charged.

Provide circuit breakers that have mechanically trip-free mechanisms with direct-current potential trip coils of the voltage indicated, auxiliary switches, latch-checking switches, control relays, and operation counters.

2.1.4.4.2 Solenoid-Operated Type

Conform to IEEE C37.121 for SF6 circuit breakers with solenoid-operated mechanisms and the appropriate articles for metal-clad switchgear rated above [600 volts] [5 kilovolts] [14.4 kilovolts].

Mount metal-clad SF6 circuit breakers on a mobile frame with primary and secondary disconnecting devices, automatic shutters, and mechanical interlocks to allow complete removal of the unit for inspection and maintenance. Provide three-pole single-throw circuit breakers, with solenoid-operated tripping/closing mechanism designed for operation [on a direct-current station battery power supply][direct from an emergency ac power system of [_____] volts].

Rate the mechanism closing coils for [125][_____] volts and operable at voltages as low as [90][_____] volts. Rate the mechanism trip coils for [125][_____] volts and operable at voltages as low as [70][_____] volts. Provide an operating mechanism for ac control circuits by the manufacturer for [_____] volts.

Provide circuit breakers with mechanically trip-free mechanisms including auxiliary switches, latch-checking switches, control relays, and operation counters. The use of solid state tripping devices is acceptable.

2.1.5 Fuses

Provide a complete set of fuses for all switches and switchgear. Provide fuses that have a voltage rating of not less than the circuit voltage.

Make no change in continuous-current rating, interrupting rating, and clearing or melting time of fuses unless written permission from the Contracting Officer has first been obtained.

Provide nonrenewable cartridge type fuses. Conform to IEEE C37.40, IEEE C37.41, IEEE C37.42, IEEE C37.46, and IEEE C37.47 as applicablefor high-voltage fuses.

Provide power fuses on ac systems above 600 volts in accordance with NEMA SG 2.

Label fuses showing UL class, interrupting rating, and time-delay characteristics, when applicable. Clearly list fuse information on equipment drawings.

Provide porcelain fuse holders when field-mounted in a cabinet or box. Do not use fuse holders made of such materials as ebony asbestos, Bakelite, or pressed fiber for field installation.

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NOTE: Relays and functions identified below represent the minimum protection requirements. Coordinate specific functions and features with project requirements and the specific relays chosen as the basis of design.

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2.1.6 Protective Relays

Provide relays capable of communications using [Modbus RTU][Modbus TCP][RS485][_____]. Ensure relays are equipped with self-checking Coordinate relay requirements with instrument transformers for proper operation.

2.1.6.1 Circuit Breaker Management/Protection Relay

Provide a microprocessor-based relay equipped with the following combination of functions including protection, monitoring, control, automation, and reporting functions:

2.1.6.1.1 Overcurrent Protection

Provide relays with [minimum 12][multiple] time overcurrent elements for phase, neutral, and ground. Ensure the relay incorporates phase and negative-sequence overcurrent elements for detection of phase faults, adaptive phase overcurrent elements that perform reliably in the presence of current transformer saturation, dc offset, and off-frequency harmonics, and residual-ground and neutral-ground overcurrent elements for detection of ground faults.

2.1.6.1.2 Under- and Overvoltage Elements

Provide relays that incorporate under- and overvoltage elements for creating protection and control schemes, including but not limited to the following: voltage checks (e.g., hot bus/dead line) for reclosing, blown transformer high-side fuse detection logic, and control schemes for capacitor banks.

2.1.6.1.3 Frequency Protection

Provide relays that with under- and overfrequency elements for detection of power system frequency disturbances. Each setting level must use an independently set timer for load shedding or generator tripping schemes. Ensure the relays also include rate-of-change-of-frequency elements with independent pickup and dropout timers, independent selection of increasing or decreasing frequency, or either.

2.1.6.1.4 Autoreclosing Control

Provide relays that incorporate a minimum four-shot recloser that includes four independently set open time intervals, an independently set reset time from reclose cycle, and an independently set reset time from lockout.

2.1.6.1.5 Synchronism Check

Ensure relays include a minimum of two synchronism-check elements with separate maximum angle settings (e.g., one for autoreclosing and one for manual closing). The synchronism-check function must compensate for breaker close time and constant phase angle differences between the two voltage sources used for synchronism check (phase angle differences settable in 30-degree increments).

2.1.6.1.6 Independent Trip/Close Pushbuttons

Ensure the relays include the option for independently operated breaker trip/close switches and indicating lamps. Ensure pushbuttons include sealable guards to prevent unauthorized operation and protection from inadvertent operation and the switch contacts include solid state protection to eliminate arcing damage and prolong contact life. The switches and breaker status lamps are to be functional regardless of the relay status.

2.1.6.1.7 Event Reporting

Ensure relays are capable of automatically recording disturbance events of 15, 30, or 60 cycles with settable prefault duration and user-defined triggering. The relay must store the event reports in nonvolatile memory.

2.1.6.2 Motor Management/Protection Relays

Provide a microprocessor-based relay equipped with the following protection, monitoring, control, automation, and reporting functions. ANSI standard device numbers in accordance with IEEE C37.2 are noted in parenthesis where applicable.

a. Motor Thermal Overload (49)

b. Integrated thermal protection for locked rotor starts, running overload, and repeated or frequent starting.

c. Phase and residual overcurrent elements (50P/50G, 51P/51G)

d. Current Unbalance/single phasing (46)

e. Phase Reversal (47)

f. Load Loss (undercurrent) (37C)

g. Notching/Jogging Device (66)

h. Start Motor Timer

2.1.6.3 Feeder Management/Protection Relays

Provide a microprocessor-based relay equipped with the following protection, monitoring, control, automation, and reporting functions. ANSI standard device numbers in accordance with IEEE C37.2 are noted in parenthesis where applicable.

a. Phase, residual, and negative-sequence overcurrent elements (50P/50G/50Q) with optional directional control.

b. Phase, residual, and negative-sequence inverse-time overcurrent elements (51P/51G/51Q) with optional directional control.

c. Neutral overcurrent and inverse-time overcurrent elements (50N/51N)

d. Breaker/contactor failure

e. Line/cable thermal elements in accordance with IEC 60255-149

f. Over- and undervoltage (59/27)

g. Inverse-time over- and undervoltage elements (59I, 27I)

h. Synchronism check (25)[

i. Autoreclosing control (79)][

j. Arc Flash detection and arc flash overcurrent (50PAF/50NAF)]

2.1.6.4 Bus Differential Relay

Provide a microprocessor-based relay equipped with the following protection, monitoring, control, and automation functions.

a. Differential protection to include low-impedance current differential elements.

b. Phase-comparator directional elements for each zone.

c. Dedicated check zones with each zone having its own adaptive differential element and settings.

d. Elements in each zone to detect CT open or short-circuit conditions.

e. Ability to invert individual or grouped CT and PT polarities to account for field wiring or zones of protection changes.

f. Internal breaker failure protection with retrip functions for each of the terminals selectable to also accept external breaker failure protection.

g. Include both instantaneous and time-overcurrent elements for each of the current inputs with torque control capability for the inverse-time overcurrent elements.

h. Three-phase over- and undervoltage elements as well as negative- and zero-sequence overvoltage elements.

i. Capability to provide protection for a fault between the open circuit breaker and the CT.

j. Capability to detect an external fault and enter into a high-security mode without blocking the differential protection at any time.

k. Use the disconnect contacts, without auxiliary relays, to create a replica of the busbar linking to assign the terminal currents to the correct differential elements.

l. Logic to ensure security of the healthy zone when the tie breaker is closed onto a fault.

m. Tie-breaker configuration capability, without any additional wiring, to be configured in any one of the following configurations: a CT on one side in overlap, CTs on either side in overlap, or CTs on either side in a separate breaker differential configuration.

2.1.7 Indicating Instruments

2.1.7.1 Ammeters

For ammeters, conform to ANSI C39.1.

Provide switchboard indicating ammeters of approximately 115 millimeter 4-1/2 inches square with 250-degree scale and recessed cases suitable for flush mounting. Furnish white dials with black figures and black pointers. Mount instruments on the hinged front panel of the switchgear compartment completely isolated from high-voltage circuits. Provide standard 5-ampere type meter for a zero to full-scale normal movement, 60 hertz.

2.1.7.2 Voltmeters

For voltmeters, conform to ANSI C39.1.

Provide a switchboard indicating voltmeters that is approximately 115 millimeter 4-1/2 inches square with 250-degree scale and recessed cases suitable for flush mounting. Furnish white dials with black figures and black pointers. Mount instruments on the hinged front panel of the switchgear compartment completely isolated from high-voltage circuits. Provide standard 120-volt type voltmeter for a zero to full-scale normal movement, 60 hertz.

2.1.7.3 Watt-Hour Meters/Wattmeters

For watt-hour meters, wattmeters, and pulse initiation meters conform to ANSI C12.1.

Provide three-phase induction type switchboard wattmeters for use with instrument transformers with two stators, each equipped with a current and potential coil. Provide meter that is rated for 5 amperes at 120 volts and is suitable for connection to three-phase, 3- and 4-wire circuits. Provide instrument complete with potential indicating lamps, light-load and full-load adjustments, phase balance, power-factor adjustments,

four-dial clock register, ratchets to prevent reverse rotation, and built-in testing facilities.

Provide pulse initiating meters for use with demand meters or pulse recorders that are suitable for use with mechanical or electrical pulse initiators. Provide mechanical load imposed on the meter by the pulse initiator that is within the limits of the pulse meter. Provide load as constant as practical throughout the entire cycle of operation to ensure accurate meter readings. Provide pulse initiating meter that is capable of measuring the maximum number of pulses at which the pulse device is nominally rated. Consider pulse initiating meter to be operating properly when a kilowatt hour check indicates that the demand meter kilowatthours are within limits of the watthour meter kilowatthours.

Locate pulse initiating meters such that components sensitive to moisture and temperature conditions are minimized. Take precautions to protect sensitive electronic metering circuitry from electromagnetic and electrostatic induction.

Furnish removable meters with draw out test plug and furnish contact devices to operate remote impulse-totalizing graphic demand meters.

Semi-flush mount case with matching cover to the hinged instrument panel.

2.1.7.4 Specialty-Type Meters

For specialty meters conform to ANSI C39.1. Specialty-type meters are panel meters applicable to specific situations, such as pyrometers and dc parameter meters that conform to the panel layout specified. Provide meter scales that are not less than 180 degrees. Do not use edgewise meters for circuit current and voltage measurements.

2.1.8 Indicating Lights

2.1.8.1 General-Purpose Type

For indicating lights, provide oiltight instrument devices with threaded base and collar for flush-mounting, translucent convex lens, candelabra screw-base lampholder, and 120-volt, 6-watt, LED lamp in accordance with ANSI C78.23. Provide indicating lights color coded in accordance with NEMA ICS 6.

Provide indicating lights in control stations when pushbuttons and selector switches are out of sight of the controller.

2.1.8.2 Switchboard Indicating Lights

For switchboard indicating lights, provide the manufacturer's standard transformer type units [120-volt input] [_____] utilizing low-voltage lamps and convex lenses of the colors indicated. Provide indicating lights that are capable of being relamped from the switchboard front. Indicating lights utilizing resistors in series with the lamps are not permitted, except in direct-current control circuits. Provide lights that have a press-to-test feature.

2.2 TEST, INSPECTIONS, AND VERIFICATIONS

2.2.1 Factory Tests

Submit factory tests certification on control and high- voltage protective devices in accordance with the manufacturer's standard practice and recommendations.

Conduct short-circuit tests in accordance with Section 2 of NEMA ICS 1 and submit to the Contracting Officer.

Submit certification of factory tests on power, high-voltage, and oil circuit breakers in accordance with IEEE C37.09.

2.2.1.1 Circuit Breaker

Perform production tests in accordance with IEEE C37.09 for each high-voltage circuit breaker. Thoroughly check each circuit breaker for proper operation and make all necessary adjustments. Check shunt trip coils for proper operation.

2.2.1.2 Instrument Transformer Test

Subject potential and current transformers to routine tests in accordance with paragraph 4.7.2 of IEEE C57.13.

Provide results of typical ratio and phase angle tests for each type and rating of instrument transformer.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Surface Protection

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NOTE: For all outdoor applications and all indoor applications in a harsh environment refer to Section 09 90 00 PAINTS AND COATINGS or 09 96 00 HIGH-PERFORMANCE COATINGS. High performance coatings are specified for all outdoor applications because ultraviolet radiation breaks down most standard coatings, causing a phenomena known as chalking, which is the first stage of the corrosion process. For additional information contact The Coatings Industry Alliance, specific suppliers such as Keeler and Long and PPG, and NACE International (NACE).

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Protect metallic materials against corrosion. Provide equipment with the standard finish by the manufacturer when used for most indoor installations. For harsh indoor environments (any area subjected to chemical and/or abrasive action), and all outdoor installations, refer to Section [09 96 00 HIGH-PERFORMANCE COATINGS][09 90 00 PAINTS AND COATINGS].

3.2 INSTALLATION

Install control devices and protective devices that are not factory

installed in equipment in accordance with the manufacturer's recommendations [and in accordance with Section 26 08 00 APPARATUS INSPECTION AND TESTING]. Field adjust and operate test devices. Conform to NFPA 70, NEMA ICS 1, NEMA ICS 2, and NEMA ICS 3 requirements for installation of control and protective devices.

3.3 FIELD QUALITY CONTROL

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

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

3.3.1 Acceptance Tests

Demonstrate that control and protective devices that are not factory installed operate as indicated.

Ratio and verify the tap settings of instrumentation, potential, and current transformers.

Conduct a timing test on circuit breakers rated 15KV to verify proper contact speed, travel, bounce, and wipe.

Conduct an insulation power factor test on all high-voltage circuit breakers and their bushings to establish condition monitoring baselines.

Perform dielectric tests and submit results on insulating oil in oil circuit breakers before the breakers are energized. Test oil in accordance with ASTM D877, and provide breakdown voltage that is not less than 25,000 volts. Provide manufacturer certification that the oil contains no PCB's and affix a label to that effect on each breaker tank and on each oil drum containing the insulating oil.

Field adjust reduced-voltage starting devices to obtain optimum operating conditions. Provide test meters and instrument transformers that conform to ANSI C12.1 and IEEE C57.13.

Do not energize control and protective devices until recorded test data has been approved by the Contracting Officer.

Perform and record results for all NETA ATS visual and mechanical inspections, standard tests, and optional tests unless otherwise indicated. Perform tests on all equipment.

Submit final test reports containing the results of all checks and tests, neatly cataloged and bound, to the Contracting Officer prior to Final Acceptance.

3.4 CLOSEOUT ACTIVITIES

3.4.1 Operation and Maintenance Manuals

No less than [30] [_____] days prior to final testing and inspection, submit Operation and Maintenance Manuals to the Contracting Officer for the following equipment:

a. High-voltage motor controllers

b. Circuit breakers

c. Protective relays

d. Indicating instruments

3.4.2 Warranty

No less than [30] [_____] days prior to project completion, submit warranty to the Contracting Officer for final review.

-- End of Section --