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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 23 June 2005

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SECTION 16475A

COORDINATED POWER SYSTEM PROTECTION

08/02

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SECTION 16475A

COORDINATED POWER SYSTEM PROTECTION
08/02

****
NOTE: This guide specification covers the requirements for the coordinated protection of power systems.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents**, including their organization designation and telephone number, is on the Internet.**

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR)**.**

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.
****

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 RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update

the issue dates.

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

****

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.11	(1987) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)
ANSI C37.06	(2000) AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis - Preferred Ratings and Related Required Capabilities
ANSI C37.16	(2000) Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors - Preferred Ratings, Related Requirements, and Application Recommendations
ANSI C37.46	(2000) For High Voltage Expulsion and Current-Limiting Type Power Class Fuses and Fuse Disconnecting Switches
ANSI C37.50	(1989; R 2000) Low-Voltage AC Power Circuit Breakers Used in Enclosures - Test Procedures

ASTM INTERNATIONAL (ASTM)

ASTM D 2472	(2000) Sulfur Hexafluoride

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2002) National Electrical Safety Code
IEEE C37.04	(1999) Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
IEEE C37.13	(1990; R 1995) Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.2	(1996) Electrical Power System Device Function Numbers and Contact Designations
IEEE C37.20.1	(2002) Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear
IEEE C37.90	(1989; R 1994) Relays and Relay Systems Associated with Electric Power Apparatus

IEEE C57.13	(1993; R 2003) Standard Requirements for Instrument Transformers
IEEE Std 242	(2001) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems - Buff Book
IEEE Std 399	(1997) Recommended Practice for Power Systems Analysis - Brown Book

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA AB 1	(2002) Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures
NEMA FU 1	(2002) Low Voltage Cartridge Fuses
NEMA ICS 1	(2000) Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2004) Industrial Controls and Systems: Controllers, Contactors, and Overload Relays Rated Not More than 2000 Volts AC or 750 Volts DC
NEMA ICS 3	(1993; R 2000) Industrial Control and Systems: Medium Voltage Controllers Rated 2001 to 7200 Volts AC
NEMA ICS 6	(1993; R 2001) Industrial Control and Systems: Enclosures
NEMA SG 2	(1993) High Voltage Fuses
NEMA SG 4	(2000) Alternating-Current High-Voltage Circuit Breaker
NEMA SG 6	(2000) Power Switching Equipment

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2005) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 198B	(1995) Class H Fuses
UL 198C	(1986; Rev thru Feb 1998)High-Interrupting-Capacity Fuses, Current-Limiting Types
UL 198D	(1995) Class K Fuses
UL 198E	(1988; Rev Jul 1988) Class R Fuses
UL 198H	(1988; Rev thru Nov 1993) Class T Fuses

UL 486E	(1994; Rev thru May 2000) Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors
UL 489	(2002; Rev thru May 2003) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 508	(1999; Rev thru Dec 2003) Industrial Control Equipment
UL 845	(1995; Rev thru Apr 2004) Motor Control Centers
UL 877	(1993; Rev thru Nov 1999) Circuit Breakers and Circuit-Breaker Enclosures for Use in Hazardous (Classified) Locations

1.2 SUBMITTALS

****

NOTE: Review submittal description (SD) definitions in Section 01330 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation 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.

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" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.][information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section

01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Fault Current Analysis
Protective Device Coordination Study

The study along with protective device equipment submittals. No time extensions or similar contact modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed will be based on recommendations of this study. The Government shall not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study.

Equipment

Data consisting of manufacturer's time-current characteristic curves for individual protective devices, recommended settings of adjustable protective devices, and recommended ratings of non-adjustable protective devices.

System Coordinator

Verification of experience and license number, of a registered Professional Engineer with at least [3] [_____] years of current experience in the design of coordinated power system protection. Experience data shall include at least five references for work of a magnitude comparable to this contract, including points of contact, addresses and telephone numbers. This engineer must perform items required by this section to be performed by a registered Professional Engineer.

Protective Relays

Data shall including calibration and testing procedures and instructions pertaining to the frequency of calibration, inspection, adjustment, cleaning, and lubrication.

Installation

Procedures including diagrams, instructions, and precautions required to properly install, adjust, calibrate, and test the devices and equipment.

SD-06 Test Reports

Field Testing

The proposed test plan, prior to field tests. Plan shall consist of complete field test procedure including tests to be performed, test equipment required, and tolerance limits, including complete testing and verification of the ground fault protection equipment, where used. Performance test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall indicate the final position of controls.

SD-07 Certificates

Devices and Equipment

Certificates certifying that all devices or equipment meet the requirements of the contract documents.

1.3 SYSTEM DESCRIPTION

****

NOTE: Provide brief, general description of the electrical power system project.

Coordinate with Section 16311A MAIN ELECTRIC SUPPLY STATION AND SUBSTATION; Section 16370A ELECTRICAL DISTRIBUTION SYSTEM, AERIAL; Section 16375A ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND; Section 16402 INTERIOR DISTRIBUTION SYSTEM.

****

The power system covered by this specification consists of: [_____].

1.4 QUALIFICATIONS

1.4.1 System Coordinator

System coordination, recommended ratings and settings of protective devices, and design analysis shall be accomplished by a registered professional electrical power engineer with a minimum of [3] [_____] years of current experience in the coordination of electrical power systems.

1.4.2 System Installer

Calibration, testing, adjustment, and placing into service of the protective devices shall be accomplished by a manufacturer's product field service engineer or independent testing company with a minimum of two years of current product experience in protective devices.

1.5 DELIVERY, STORAGE, AND HANDLING

Devices and equipment shall be visually inspected when received and prior to acceptance from conveyance. Stored items shall be protected from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced.

1.6 PROJECT/SITE CONDITIONS

****

NOTE: Unusual service conditions for altitude start above 1005 m (3300 feet) for most apparatus. Unusual ambient temperature ranges are minus 30 to 40 degrees C, but other ambients may apply. Frequency is generally 60 Hz, although 50 Hz may also be standard. Fungus control for electrical devices is required only in tropical areas.

Provide seismic requirements, if a Government

designer is the Engineer of Record, and show on the drawings. Delete the inappropriate bracketed phrase. Sections 13080, 15070A and 16070A, properly edited, must be included in the contract documents.
****

Devices and equipment furnished under this section shall be suitable for the following site conditions. Seismic details shall [conform to Sections 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT, 15070A SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT AND 16070A SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT] [be as indicated].

1.6.1 Altitude

Altitude: [_____]

1.6.2 Ambient Temperature

Ambient Temperature: [_____]

1.6.3 Frequency

Frequency: [_____]

1.6.4 Fungus Control

Fungus Control: [_____]

1.6.5 Hazardous Classification

Hazardous Classification: [_____]

1.6.6 Humidity Control

Humidity Control: [_____]

1.6.7 Ventilation

Ventilation: [_____]

1.6.8 Seismic Parameters

Seismic Parameters: [_____]

1.6.9 Other

Other: [_____]

1.7 EXTRA MATERIALS

The following spare fuses or spare fuse elements shall be delivered to the Contracting officer when the electrical system is accepted:

FUSE TYPE/CLASS	VOLTAGE	CURRENT	NO. OF SPARES
[_____]	[_____]	[_____]	[_____]

PART 2 PRODUCTS

****
NOTE: Select types to suit project conditions and delete all others. Delete all paragraphs not applicable.
****

2.1 STANDARD PRODUCT

Protective devices and equipment shall be the standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory utility type use for at least two years prior to bid opening.

2.2 NAMEPLATES

Nameplates shall be provided to identify all protective devices and equipment. Nameplate information shall be in accordance with NEMA AB 1 or NEMA SG 6 as applicable.

2.3 CORROSION PROTECTION

Metallic materials shall be protected against corrosion. Ferrous metal hardware shall be zinc or chrome-plated.

2.4 MOTOR CONTROLS AND MOTOR CONTROL CENTERS

Motor controls and motor control centers shall be in accordance with NEMA ICS 1, NEMA ICS 2, NEMA ICS 3 and NEMA ICS 6, and UL 508and UL 845.

2.4.1 Motor Starters

Combination starters shall be provided with [circuit breakers] [and] [fusible switches] [and] [switches equipped with high-interrupting-capacity current-limiting fuses] [as indicated].

2.4.2 Reduced-Voltage Starters

****
NOTE: Reduced voltage starters will be required when the locked rotor current of motors exceeds the full-load rating of supply transformers or supply conductors.
****

Reduced-voltage starters shall be provided for polyphase motors [_____] kW ([_____] hp) [_____] hpor larger. Reduced-voltage starters shall be of the single-step autotransformer, reactor, or resistor type having an adjustable time interval between application of reduced and full voltages to the motors. Wye-delta reduced voltage starter or part winding increment starters having an adjustable time delay between application of voltage to first and second winding of motor, may be used in lieu of the reduced voltage starters specified above for starting of motor-generator sets, centrifugally operated equipment or reciprocating compressors provided with automatic unloaders.

2.4.3 Thermal-Overload Protection

Each motor of 93 W (1/8 hp) 1/8 hp or larger shall be provided with thermal-overload protection. Polyphase motors shall have overload protection in each ungrounded conductor. The overload-protection device shall be provided either integral with the motor or controller, or shall be mounted in a separate enclosure. Unless otherwise specified, the protective device shall be of the manually reset type. Single or double pole tumbler switches specifically designed for alternating-current operation only may be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating.

2.4.4 Low-Voltage Motor Overload Relays

****
NOTE: In most cases, thermal relays will be specified. Standard, slow, and quick-acting trip units are available. Magnetic relays are used to protect low-voltage motors with long starting times or unusual duty cycles.
****

2.4.4.1 General

[Thermal] [and] [magnetic current] overload relays shall conform to NEMA ICS 2 and UL 508. Overload protection shall be provided either integral with the motor or controller, and shall be rated in accordance with the requirements of NFPA 70. [Standard units shall be used for motor starting times up to 7 second.] [Slow units shall be used for motor starting times from 8 to 12 seconds.] [Quick trip units shall be used on hermetically sealed, submersible pumps, and similar motors.]

2.4.4.2 Construction

Manual reset type thermal relays shall be [melting alloy] [bimetallic] construction. Automatic reset type relays shall be bimetallic construction. Magnetic current relays shall consist of a contact mechanism and a dash pot mounted on a common frame.

2.4.4.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Trip current ratings shall be established by selection of the replaceable overload device and shall not be adjustable. Where the controller is remotely-located or difficult to reach, an automatic reset, non-compensated overload relay shall be provided. Manual reset overload relays shall be provided otherwise, and at all locations where automatic starting is provided. Where the motor is located in a constant ambient temperature, and the thermal device is located in an ambient temperature that regularly varies by more than minus 10 degrees C, 14 degrees F, an ambient temperature-compensated overload relay shall be provided.

2.4.5 Automatic Control Devices

2.4.5.1 Direct Control

Automatic control devices (such as thermostats, float or pressure switches) which control the starting and stopping of motors directly shall be designed for that purpose and have an adequate kilowatt horsepowerrating.

2.4.5.2 Pilot-Relay Control

Where the automatic-control device does not have such a rating, a magnetic starter shall be used, with the automatic-control device actuating the pilot-control circuit.

2.4.5.3 Manual/Automatic Selection

a. Where combination manual and automatic control is specified and the automatic-control device actuates the pilot control circuit of a magnetic starter, the magnetic starter shall be provided with a three-position selector switch marked MANUAL-OFF-AUTOMATIC.

b. Connections to the selector switch shall only allow the normal automatic regulatory control devices to be bypassed when the switch is in the Manual position; all safety control devices, such as low-or high-pressure cutouts, high-temperature cutouts, and motor-overload protective devices, shall be connected in the motor-control circuit in both the Manual and the Automatic positions of the selector switch. Control circuit connections to any MANUAL-OFF-AUTOMATIC switch or to more than one automatic regulatory control device shall be made in accordance with wiring diagram approved by the contracting Officer unless such diagram is included on the drawings. All controls shall be 120 volts or less unless otherwise indicated.

2.4.6 Motor Control Centers

Control centers shall be indoor type and shall contain combination starters and other equipment as indicated. Control centers shall be NEMA ICS 2, Class [_____], Type [_____]. Each control center shall be mounted on floor sills or mounting channels. Each circuit shall have a suitable metal or laminated plastic nameplate with white cut letters. Motor control centers shall be provided with a full-length ground bus bar.

2.5 LOW-VOLTAGE FUSES

2.5.1 General

Low-voltage fuses shall conform to NEMA FU 1. Time delay and nontime delay options shall be as [shown] [specified]. Equipment provided under this contract shall be provided with a complete set of properly rated fuses when the equipment manufacturer utilizes fuses in the manufacture of the equipment, or if current-limiting fuses are required to be installed to limit the ampere-interrupting capacity of circuit breakers or equipment to less than the maximum available fault current at the location of the equipment to be installed. Fuses shall have a voltage rating of not less than the phase-to-phase circuit voltage, and shall have the time-current characteristics requires for effective power system coordination.

2.5.2 Cartridge Fuses; Noncurrent-Limiting Type

Cartridge fuses of the noncurrent-limiting type shall be Class H, nonrenewable, dual element, time lag type and shall have interrupting capacity of 10,000 amperes. Class H Fuses shall conform to UL 198B. At 500 percent current, cartridge fuses shall not blow in less than 10 seconds. Cartridge fuses shall be used for circuits rated in excess of 30 amperes, 125 volts, except where current-limiting fuses are indicated.

2.5.3 Cartridge Fuses; Current-Limiting Type

****
NOTE: Class RKI provides high current limitation with both time-delay and nontime-delay. RK5 provides moderate current limitation, time-delay option.
****

Cartridge fuses, current-limiting type, Class [G] [J] [K] [L] [RK1] [RK5] [RK9] [T] [CC] shall have tested interrupting capacity not less than [100,000] [200,000] amperes. Fuse holders shall be the type that will reject Class H fuses.

a. Class [G] [J] [L] [CC] fuses shall conform to UL 198C.

b. Class K fuses shall conform to UL 198D.

c. Class R fuses shall conform to UL 198E.

d. Class T fuses shall conform to UL 198H.

2.5.3.1 Continuous Current Ratings (600 amperes and smaller)

****
NOTE: Class J or RK1 provide best protection for services and feeders rated 600 amperes or less. Class RK5 may be more cost effective where the greater current limitation of RK1 or J is not a requirement.
****

Service entrance and feeder circuit fuses (600 amperes and smaller) shall be Class [RK1] [RK5] [J], current-limiting, [nontime-delay] [time-delay] with 200,000 amperes interrupting capacity.

2.5.3.2 Continuous Current Ratings (greater than 600 amperes)

Service entrance and feeder circuit fuses (greater than 600 amperes) shall be Class L, current-limiting, [nontime-delay] [time-delay] with 200,000 amperes interrupting capacity.

2.5.3.3 Motor and Transformer Circuit Fuses

Motor, motor controller, transformer, and inductive circuit fuses shall be Class RK1 or RK5, current-limiting, time-delay with 200,000 amperes interrupting capacity.

2.6 MEDIUM-VOLTAGE AND HIGH-VOLTAGE FUSES

2.6.1 General

Medium-voltage and high-voltage fuses shall conform to NEMA SG 2 and shall be distribution fuse cutouts or power fuses, E-rated, C-rated, or R-rated current-limiting fuses as shown.

2.6.2 Construction

Units shall be suitable for [outdoor] [indoor] use. Fuses shall have integral blown-fuse indicators. All ratings shall be clearly visible.

2.6.3 Ratings

****
NOTE: Select fuse ratings to suit project conditions and delete all others.
****

Voltage ratings shall be not less than the applicable circuit voltage. Continuous-current ratings shall be as shown.

2.6.3.1 Fuse Cutouts

Medium-voltage fuses and cutouts shall comply with NEMA SG 2 and shall be of the [loadbreak] [nonloadbreak] [enclosed] [open] type construction [rated [5.2] [7.8] [15] [27] [28] kV and of the [normal] [heavy] [extra-heavy] [ultra-heavy] -duty type] [ratings and types indicated]. Open-link cutouts are not acceptable. Fuses shall be either indicating or dropout type. Fuse ratings shall be as indicated. Fuses cutouts shall be equipped with mounting brackets suitable for the indicated installations.

2.6.3.2 Power Fuses

[Expulsion-type] [Current-limiting] power fuses shall have ratings in accordance with ANSI C37.46 and as follows:

a. Nominal voltage....................................[_____]

b. Rated maximum voltage..............................[_____]

c. Maximum symmetrical interrupting capacity..........[_____]

d. Rated continuous current...........................[_____]

e. BIL..[_____]

2.6.3.3 E-Rated, Current-Limiting Power Fuses

E-rated, current-limiting, power fuses shall conform to ANSI C37.46.

2.6.3.4 C-Rated, Current-Limiting Fuses

C-rated, current-limiting, power fuses shall open in 1000 seconds at currents between 170 and 240 percent of the C rating.

2.6.3.5 R-Rated, Current-Limiting Fuses

R-rated, current-limiting, fuses shall be used with medium-voltage motor controllers only. R-rated fuses shall conform to ANSI C37.46.

2.7 MOTOR SHORT-CIRCUIT PROTECTOR (MSCP)

****
NOTE: MSCPs are components of motor controllers rather than fuses. MSCPs, therefore, have no ampere

ratings and are identified by letter designations, A-Y. Due to a limited number of MSCP manufacturers, MSCPs should be used only as a sole-source item.
****

2.7.1 General

Motor short-circuit protectors shall conform to UL 508 and shall be provided as shown. Protectors shall be used only as part of a combination motor controller which provides coordinated motor branch-circuit overload and short-circuit protection, and shall be rated in accordance with the requirements of NFPA 70.

2.7.2 Construction

Motor short-circuit protector bodies shall be constructed of high temperature, dimensionally stable, long life, nonhygroscopic materials. Protectors shall fit special MSCP mounting clips and shall not be interchangeable with any commercially available fuses. Protectors shall have 100 percent one-way interchangeability within the A-Y letter designations. All ratings shall be clearly visible.

2.7.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Letter designations shall be A through Y for motor controller Sizes 0, 1, 2, 3, 4, and 5, with 100,000 amperes interrupting capacity rating. Letter designations shall correspond to controller sizes as follows:

CONTROLLER SIZE	MSCP DESIGNATION
NEMA 0	A-N
NEMA 1	A-P
NEMA 2	A-S
NEMA 3	A-U
NEMA 4	A-W
NEMA 5	A-Y

2.8 MOLDED-CASE CIRCUIT BREAKERS

2.8.1 General

Molded-case circuit breakers shall conform to NEMA AB 1 and UL 489. Circuit breakers may be installed in panelboards, switchboards, enclosures, motor control centers, or combination motor controllers. Circuit breakers and circuit breaker enclosures located in hazardous (classified) areas shall conform to UL 877.

2.8.2 Construction

Molded-case circuit breakers shall be assembled as an integral unit in a supporting and enclosing housing of glass reinforced insulating material providing high dielectric strength. Circuit breakers shall be suitable for mounting and operating in any position. Lugs shall be listed for [copper conductors only] [copper and aluminum conductors] in accordance with UL 486E. Single-pole circuit breakers shall be full module size with not more than one pole per module. Multi-pole circuit breakers shall be of the common-trip type having a single operating handle such that an overload or short circuit on any one pole will result in all poles opening simultaneously. Sizes of 100 amperes or less may consist of single-pole breakers permanently factory assembled into a multi-pole unit having an internal, mechanical, nontamperable common-trip mechanism and external handle ties. All circuit breakers shall have a quick-make, quick-break overcenter toggle-type mechanism, and the handle mechanism shall be trip-free to prevent holding the contacts closed against a short-circuit or sustained overload. All circuit breaker handles shall assume a position between "ON" and "OFF" when tripped automatically. All ratings shall be clearly visible.

2.8.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. The interrupting rating of the circuit breakers shall be at least equal to the available short-circuit current at the line terminals of the circuit breaker and correspond to the UL listed integrated short-circuit current rating specified for the panelboards and switchboards. Molded-case circuit breakers shall have nominal voltage ratings, maximum continuous-current ratings, and maximum short-circuit interrupting ratings in accordance with NEMA AB 1. Ratings shall be coordinated with system X/R ratio.

2.8.4 Cascade System Ratings

Circuit breakers used in series combinations shall be in accordance with UL 489. Equipment, such as switchboards and panelboards, which house series-connected circuit breakers shall be clearly marked accordingly. Series combinations shall be listed in the UL Recognized Component Directory under "Circuit Breakers-Series Connected."

2.8.5 Thermal-Magnetic Trip Elements

Thermal magnetic circuit breakers shall be provided as shown. Automatic operation shall be obtained by means of thermal-magnetic tripping devices located in each pole providing inverse time delay and instantaneous circuit protection. The instantaneous magnetic trip shall be adjustable and accessible from the front of all circuit breakers on frame sizes above [150] [_____] amperes.

2.8.6 Solid-State Trip Elements

Solid-state circuit breakers shall be provided as shown. All electronics shall be self-contained and require no external relaying, power supply, or accessories. Printed circuit cards shall be treated to resist moisture absorption, fungus growth, and signal leakage. All electronics shall be housed in an enclosure which provides protection against arcs, magnetic interference, dust, and other contaminants. Solid-state sensing shall measure true RMS current with error less than one percent on systems with distortions through the 13th harmonic. Peak or average actuating devices are not acceptable. Current sensors shall be toroidal construction, encased in a plastic housing filled with epoxy to protect against damage and moisture and shall be integrally mounted on the breaker. Where indicated on the drawings, circuit breaker frames shall be rated for 100 percent continuous duty. Circuit breakers shall have tripping features as shown on the drawings and as described below:

a. Long-time current pick-up, adjustable from 50 percent to 100 percent of continuous current rating.

b. [Fixed] [Adjustable] long-time delay.

c. Short-time current pick-up, adjustable from 1.5 to 9 times long-time current setting.

d. [Fixed] [Adjustable] short-time delay.

e. [Short-time I square times t switch.]

f. Instantaneous current pick-up, adjustable from 1.5 to 9 times long-time current setting.

g. Ground-fault pick-up, adjustable from 20 percent to 60 percent of sensor rating, but in no case greater than 1200 amperes. Sensing of ground-fault current at the main bonding jumper or ground strap shall not be permitted. [Zone-selective interlocking shall be provided as shown.]

h. [Fixed] [Adjustable] ground-fault delay.

i. [Ground-fault I square times t switch.]

j. [Overload] [and] [Short-circuit] [and] [Ground-fault] trip indicators shall be provided.

2.8.7 Current-Limiting Circuit Breakers

Current-limiting circuit breakers shall be provided as shown. Current-limiting circuit breakers shall limit the let-through I square times t to a value less than the I square times t of one-half cycle of the symmetrical short-circuit current waveform. On fault currents below the threshold of limitation, breakers shall provide conventional overload and short-circuit protection. Integrally-fused circuit breakers shall not be used.

2.8.8 SWD Circuit Breakers

Circuit breakers rated 15 amperes or 20 amperes and intended to switch 277 volts or less fluorescent lighting loads shall be marked "SWD."

2.8.9 HACR Circuit Breakers

Circuit breakers 60 amperes or below, 240 volts, 1-pole or 2-pole, intended to protect multi-motor and combination-load installations involved in heating, air conditioning, and refrigerating equipment shall be marked "Listed HACR Type."

2.8.10 Motor Circuit Protectors (MCP)

****

NOTE: A motor circuit protector (MCP) is defined as an adjustable, instantaneous trip circuit breaker used in conjunction with a combination motor controller having overload protection.

****

Motor circuit protectors shall conform to NEMA AB 1 and UL 489 and shall be provided as shown. MCPs shall consist of an adjustable instantaneous trip circuit breaker in conjunction with a combination motor controller which provides coordinated motor circuit overload and short-circuit protection. Motor Circuit Protectors shall be rated in accordance with NFPA 70.

2.9 LOW-VOLTAGE POWER CIRCUIT BREAKERS

2.9.1 Construction

Low-voltage power circuit breakers shall conform to IEEE C37.13, ANSI C37.16, and NEMA SG 6 and shall be three-pole, single-throw, stored energy, [manually] [electrically] operated, with drawout mounting. Solid-state trip elements which require no external power connections shall be provided. Circuit breakers shall have an open/close contact position indicator, charged/discharged stored energy indicator, primary disconnect devices, and a mechanical interlock to prevent making or breaking contact of the primary disconnects when the circuit breaker is closed. Control voltage shall be [24 V dc] [48 V dc] [120 V ac] [as indicated.] The circuit breaker enclosure shall be suitable for its intended location.

2.9.2 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Circuit breakers shall be rated for 100 percent continuous duty and shall have trip current ratings and frame sizes as shown. Nominal voltage ratings, maximum continuous-current ratings, and maximum short-circuit interrupting ratings shall be in accordance with ANSI C37.16. Tripping features shall be as follows:

a. Long-time current pick-up, adjustable from 50 percent to 100 percent of sensor current rating.

b. Adjustable long-time delay.

c. Short-time current pick-up, adjustable from 1.5 to 9 times long-time current setting.

d. Adjustable short-time delay.

e. [Short-time I square times t switch.]

f. Instantaneous current pick-up, adjustable from 1.5 to 9 times long-time current setting.

g. Ground-fault pick-up, adjustable from 20 percent to 60 percent of sensor rating, but in no case greater than 1200 amperes. Sensing of ground-fault current at the main bonding jumper or ground strap shall not be permitted. [Zone-selective interlocking shall be provided as shown.]

h. [Fixed] [Adjustable] ground-fault delay.

i. [Ground-fault I square times t switch.]

j. [Overload] [and] [Short-circuit] [and] [Ground-fault] trip indicators shall be provided.

2.10 MEDIUM-VOLTAGE CIRCUIT BREAKERS/INTERRUPTERS

2.10.1 Metal-Enclosed Type

Circuit breakers shall be of the drawout type, in accordance with IEEE C37.20.1 and NEMA SG 6.

2.10.2 Metal-Clad Type

Circuit breakers shall comply with IEEE C37.04 and shall consist of items listed for such units in NEMA SG 6.

2.10.3 SF6 Interrupters

SF6 interrupters shall be of the puffer type where the movement of the contact plunger will initiate the puff of SF6 gas across the contact to extinguish the arc at zero gauge tank pressure (atmospheric pressure). The puff of SF6 must be sufficient to clear an arc for [15 kV] [_____] or lower class equipment and remain operational without damage or requiring maintenance or repair except for gas leaks. Breakers shall be provided with a loss-of-pressure alarm remote as shown on the drawings. Before the pressure in the container drops below the point where the breaker or switch cannot open safely without damage, the breaker shall activate the loss-of-pressure alarm, open automatically, and remain in the locked open position until repaired. If located inside a structure, breakers shall be located in a closed room with access only from outside, and provided with direct outdoor ventilation and a sensor unit which activates a vent fan and an alarm when a SF6 leak had occurred. The alarm will automatically be silenced when the oxygen in the room is above 19.5 percent. The SF6 shall meet the requirements of ASTM D 2472, except that the maximum dew point shall be minus 60 degrees C 140 degrees F(corresponding to 11 ppm water by volume), with only 11 ppm water by volume, and the minimum purity shall be 99.9 percent by weight. Circuit breakers shall have provisions for maintenance slow closing of contacts and have a readily accessible contact wear indicator. Tripping time shall not exceed five cycles.

2.10.4 Vacuum Interrupters

Vacuum interrupters shall be hermetically-sealed in a high vacuum to protect contact from moisture and contamination. Circuit breakers shall have provisions for slow closing of contacts and have a readily contact wear indicator. Tripping time shall not exceed five cycles.

2.10.5 Ratings

****

NOTE: ANSI C37.06, Table 2 lists preferred ratings for indoor oilless circuit breakers. A short-circuit study is required to specify ratings.

****

Main buses shall be three-phase [three-wire] [four-wire] with a continuous current rating of [_____] amperes rms. [The neutral bus shall be rated for [_____] amperes, continuous.] Switchgear ratings at 60 Hz shall be in accordance with ANSI C37.06 and as follows:

Maximum voltage.................................[_____]

Nominal voltage class...........................[_____]

BIL...[_____]

Maximum symmetrical interrupting capacity.........[_____]

3-second short-time-current carrying capacity.....[_____]

Rated continuous current...............[as shown] [_____]

2.11 OIL CIRCUIT BREAKERS FOR SUBSTATIONS

****
NOTE: ANSI C37.06 lists standard ratings. A short-circuit study is required to specify ratings.
****

Oil circuit breakers shall comply with IEEE C37.04 and NEMA SG 4and shall be of the outdoor three-pole type, with single or multiple tanks and frame-mounted or floor-mounted on a common base in accordance with the manufacturer's standard design. Control voltage shall be [48] [125] volts dc. Ratings shall be as follows:

Nominal voltage.............................[_____]

Rated maximum voltage.......................[_____]

Maximum symmetrical interrupting capacity.....[_____]

Maximum asymmetrical interrupting capacity....[_____]

3-second short time current carrying capacity.[_____]

Close and latch capacity....................[_____]

Rated continuous current....................[_____]

Maximum interrupting time...................[_____]

Permissible tripping delay..................[_____]

Reclosing time (adjustment range)............[_____]

Duty cycle at rated conditions...............[_____]

Basic Insulation Level (BIL).................[_____]

2.11.1 Incoming Line Circuit Breakers for Substations

****
NOTE: Delete items "e" and "f" if not required.
****

Incoming line circuit breakers shall be coordinated with the requirements of the serving utility, and of the protected transformer, and shall include the following control and monitoring system items that shall be mounted in the instrument and relay cabinet.

a. An ammeter and an ammeter switch.

b. A circuit breaker control switch for local and remote control operation.

c. Three overcurrent relays, devices 50/51.

d. One residually-connected ground-overcurrent relay, device 50/51N.

e. Three directional overcurrent relays, device 67.

f. One ground-directional-overcurrent relay, device 67N.

g. Three transformer differential relays, device 87T and an auxiliary lockout relay, device 86T located in the [associated metal-clad switchgear] [instrument and relay cabinet].

h. [Single] [Three] phase secondary potential test blocks with associated test plug, quantity as shown.

i. [Single] [Three] phase secondary current test blocks with associated test plug for [each current transformer circuit] [each three-phase set of current transformers], as indicated.

j. [_____]

2.11.2 Line Tie Circuit Breakers for Substations

****
NOTE: Delete either 86B or 87B relays if not required.
****

The line tie circuit breaker shall be rated [as shown] [the same as the incoming line units], and shall be electrically and mechanically interlocked with other high-voltage items of equipment as shown. The line tie circuit breaker shall be equipped with control and monitoring system items the same as described for the incoming line circuit breaker. The instrument and relay cabinet shall house the same equipment listed for the incoming line circuit breaker cabinet except [_____]. The cabinet shall also house three bus differential relays, device 87B, and an auxiliary lockout relay, device 86B.

2.12 SUBSTATION AND SWITCHGEAR PROTECTIVE RELAYS

****
NOTE: Ranges selected will be based on the coordination study. Refer to TM 5-811-1 and TM 5-811-14 for guidance regarding protective relays.
****

[Solid-state] [and] [Electromechanical] [and] [Microprocessor-based] protective relays shall be as shown and shall be of a type specifically designed for use on power switchgear or associated electric power apparatus. Protective relays shall conform to IEEE C37.90. Relays and auxiliaries shall suitable for operation with the instrument transformer ratios and connections provided.

2.12.1 Construction

Relays for installation in metal-clad switchgear shall be of the semi-flush, rectangular, back-connected, dustproof, switchboard type. Cases shall have a black finish and window-type removable covers capable of being sealed against tampering. Relays shall be of a type that can be withdrawn, through approved sliding contacts, from fronts of panels or doors without opening current transformer secondary circuits, disturbing external circuits, or requiring disconnection of any relay leads. Necessary test devices shall be incorporated within each relay and shall provide a means for testing either from an external source of electric power or from associated instrument transformers. Each relay shall be provided with an operation indicator and an external target reset device. Relays shall have necessary auxiliaries for proper operation. Relays and auxiliaries shall be suitable for operation with the instrument transformer ratios and connections provided.

2.12.2 Ratings

Relays shall be the manufacturer's standard items of equipments with appropriate ranges for time dial, tap, and other settings. Relay device numbers shall correspond to the function names and descriptions of IEEE C37.2.

2.12.3 Overcurrent Relays

****

NOTE: Ranges selected will be based on the coordination study. Refer to TM 5-811-1 and TM 5-811-14 for guidance regarding protective relays.

****

Overcurrent relays shall be as follows:

a. Phase overcurrent relays for main [and tie] circuit breakers shall be single-phases, nondirectional, [induction] [solid-state] [microprocessor-based] type, time delay, device 51, current taps [[_____] to [_____] amperes] [as indicated] with characteristic curves that are [definite time] [moderately inverse] [inverse] [very inverse] [extremely inverse] [as indicated].

b. Ground overcurrent relays for main circuit breakers shall be nondirectional, [induction] [solid-state] [microprocessor-based] type, time delay, device [51G wired to a current transformer in the source transformer neutral-to-ground connection] [51N, residually connected], with current taps [[_____] to [_____] amperes] [as indicted] and with characteristic curves that are [definite time] [moderately inverse] [inverse] [very inverse] [extremely inverse] [as indicated].

c. Ground overcurrent relays for tie circuit breakers shall be nondirectional, [induction] [solid-state] [microprocessor-based] type, time delay, device 51N, residually connected, with current taps [[_____] to [_____] amperes] [as indicated] and with characteristic curves that are [definite time] [moderately inverse] [inverse] [very inverse] [extremely inverse] [as indicated].

d. Phase overcurrent relays for feeder circuit breakers shall be single-phase, nondirectional, [induction] [solid-state] [microprocessor-based] type, device 50/51, with instantaneous-current pick-up range [[_____] to [_____] amperes] [as indicated], with time-delay-current taps [[_____] to [_____] amperes] [as indicated] and with characteristic curves that are [definite time] [moderately inverse] [inverse] [very inverse] [extremely inverse] [as indicated].

e. Ground overcurrent relays for feeder circuit breakers shall be nondirectional, [plunger] [solid-state] [microprocessor-based] type instantaneous, device [50GS wires to a ground sensor current transformer] [50N, residually connected], with current pick-up range [[_____] to [_____] amperes] [as indicated].

2.12.4 Directional Overcurrent Relays

Directional overcurrent relays shall be as follows:

a. Directional phase overcurrent relays shall be single-phase, [induction] [solid-state] [microprocessor-based] type, with instantaneous units. Phase relays, device 67, shall have an instantaneous-current pick-up range [[_____] to [_____] amperes] [as indicated], with time-delay-current taps [[_____] to [_____] amperes] [as indicated] and with characteristic curves that are [definite time] [moderately inverse] [inverse] [very inverse] [extremely inverse] [as indicated].

b. Directional ground overcurrent relays, device 67N, shall have an instantaneous-current pick-up range [[_____] to [_____] amperes] [as indicated], with time-delay-current taps [[_____] to [_____] amperes] [as indicated] and with characteristic curves that are [definite time] [moderately inverse] [inverse] [very inverse] [extremely inverse] [as indicated].

2.12.5 Automatic Reclosing Relay

Relay, device 79, shall be of the three-phase, four-reclosure type, providing immediate initial reclosure, and three time-delay reclosures. Adjustable time delays shall be 10 to 60 seconds for reset and 0 to 45 seconds for reclosing. Units shall have instantaneous trip lockout after any preset trip when closing in on a fault. Auxiliary devices shall provided for lockout when an associated circuit breaker is tripped after reclosures and automatically reset when an associated circuit breaker is not tripped after any reclosure.

2.12.6 Transformer Differential and Lockout Relays

Differential relays, device 87T, shall be of the three-phase or the single-phase high-speed [_____] [percentage] [_____] differential type suitable for the protection of two-winding transformers, and shall be provided with a harmonic-restraint feature. Lockout relay, device 86T, shall be of the type which, when used in conjunction with the 87T relay, trips and locks out the indicated circuit breakers.

2.12.7 Bus Differential and Lockout Relays

Bus differential relay, device 87B, shall be of the three-phase or single-phase, high-speed impedance differential type suitable for protection of buses. Lockout relay, device 86B, shall be of a type which, when used in conjunction with the 87B relay, trips and locks out the indicated circuit breaker.

2.13 INSTRUMENT TRANSFORMERS

2.13.1 General

Instrument transformers shall comply with ANSI C12.11 and IEEE C57.13. Instrument transformers shall be configured for mounting in/on the device to which they are applied. Polarity marks on instrument transformers shall be visually evident and shown on the drawings.

2.13.2 Current Transformers

****
NOTE: See TM 5-811-1 regarding guidance on current transformers. Accuracy class ratings of current transformers (CTs) at standard burdens are listed in IEEE C57.13. The minimum standard current transformer accuracies for metal-clad switchgear are listed in ANSI C37.20.2. In general, ANSI C12.11 requires a 0.3 accuracy class for up to a B-0.5 burden, except for some 200 and 400 ampere units. Where metering current transformers are provided, this accuracy class should be specified, if available for the ampere and burden needed. A "C" classification means the ratio error can be calculated, whereas a "T" classification is one which has to be derived by testing. ANSI C37.20.2 permits either classification up to indicated ratings.
****

Unless otherwise indicated, bar, wound, or window-type transformers are acceptable; and except for window-type units installed over insulated buses, transformers shall have a BIL rating consistent with the rated BIL of the associated switchgear or electric power apparatus bushings, buses or conductors. Current transformers shall have the indicated ratios. The continuous thermal-current rating factor shall be not less than [1.0] [1.2] [1.5] [2.0] [3.0] [4.0]. Other thermal and mechanical ratings of current transformers and their primary leads shall be coordinated with the design of the circuit breaker and shall be not less than the momentary rating of the associated circuit breaker. Circuit protectors shall be provided across secondary leads of the current transformers to prevent the accidental open-circuiting of the transformers while energized. Each terminal of each current transformer shall be connected to a short-circuiting terminal block in the circuit interrupting mechanism cabinet, power transformer terminal cabinet, and in the associated instrument and relay cabinets.

2.13.2.1 Current transformers For Oil Circuit Breakers

[Single-ratio] [Multi-ratio] bushing type current transformers shall be provided in circuit breaker bushing wells as indicated. [Single-ratio units shall have a minimum metering accuracy class rating of [0.6B-0.5] [0.3B-0.5].] [Multi-ratio units shall have a minimum relaying accuracy voltage class of [_____] for either a C or T classification.]

2.13.2.2 Current Transformers for Power Transformers

****
NOTE: ANSI C57.12.10, Table 20 gives recommended

values.
****

[Single-ratio] [Multi-ratio] bushing type current transformers shall be provided internally around power transformer bushings as shown. [Single-ratio units shall have a minimum metering accuracy class of [0.6B-0.5] [0.3B-0.5].] [Multi-ratio units shall have a minimum relaying accuracy voltage class of [_____] for either a C or T classification.]

2.13.2.3 Current Transformers for Metal-Clad Switchgear

Single-ratio units, used for metering and relaying, shall have a metering accuracy class rating of [_____] [B_____]. Single-ratio units, used only for relaying, shall have a relaying accuracy class rating of [_____] for [either] a C [or T] classification.

2.13.2.4 Current Transformers for kW Hour and Demand Metering (Low Voltage)

****
NOTE: Use the following guidelines for specifying current transformers.

a. Select the standard current transformer (CT) primary rating which is just below the full load current of the serving power transformer i.e., for 500 kVA transformer with a full load of 1387 amps at 208 volts - select a 1200/5 CT ratio; for a 750 kVA transformer with a full load of 902 amps at 480 volts - select a 800/5 CT ratio.

b. Select a continuous-thermal-current rating factor (RF) in accordance with the following table:

RATIO	RF at 30 degrees C
200/5	4.0
300/5	3.0
400/5	4.0
600/5	3.0
800/5	2.0
1200/5	1.5
1500/5	1.5
2000/5	1.5
3000/5	1.33

c. Select ANSI Metering Accuracy Class in accordance with the following table:

Primary Amp Rating (of CT)	Accuracy Class
200	0.3 thru B-0.1
300-400	0.3 thru B-0.2
600-1200	0.3 thru B-0.5
1500	0.3 thru B-0.9
2000-3000	0.3 thru B-1.8

****

Current transformers shall conform to IEEE C57.13. Current transformers with a metering accuracy Class of 0.3 through [_____], with a minimum RF of

[_____] at 30 degrees C, 86 degrees F, with 600-volt insulation, and 10 kV BIL shall be provided. Butyl-molded, window-type current transformers mounted [on the transformer low-voltage bushings shall be provided. Route current transformer leads in a location as remote as possible from the power transformer secondary cables to permit current measurements to be taken with hook-on-ammeters.] [in the current transformer cabinet shall be provided.]

2.13.2.5 Voltage Transformers

****

NOTE: See TM 5-811-1 for guidance regarding voltage transformers. Minimum standard potential transformer accuracies for metal-clad switchgear are not listed in ANSI C37.20.2. Accuracy classes as listed in IEEE C57.13 are 0.3, 0.6, and 1.2. Standard burdens for each accuracy class are W, X, Y, Z, ZZ, and M. The designer should check the burdens connected to determine the actual accuracy class and burden required. In general, ANSI C12.11 requires 0.3 accuracy class for up to Y burdens, except for voltages of 5 kV and below. Where metering potential transformers are provided, a 0.3 accuracy class should be specified, if available for the voltage rating and burden needed.

****

Voltage transformers shall have indicated ratios. Units shall have an accuracy rating of [_____]. Voltage transformers shall be of the drawout type having current-limiting fuses in both primary and secondary circuits. Mechanical interlocks shall prevent removal of fuses, unless the associated voltage transformer is in a drawout position. Voltage transformer compartments shall have hinged doors.

2.14 COORDINATED POWER SYSTEM PROTECTION

****

NOTE: The requirements for the studies in these paragraphs depend on the complexity and extent of the power system. Delete these requirements for: projects of limited scope; projects having protective devices which are not adjustable or for which coordination is not possible (standard molded case circuit breakers); projects involving simple extension of 600 volt level service to a building or facility from an existing transformer (750 kVA or less); or projects involving simple extension of 600 volt level service to a building or facility from a new transformer (750 kVA or less).

The designer will be responsible for showing and specifying the requirements for fuses, circuit breakers, protective relays, or other protective devices associated with the project. The protective devices should be selected and specified to protect electrical power system conductors or equipment against sustained overloads, in-rush conditions, electrical faults, or other abnormal power system or equipment operating conditions, in accordance with

TM 5-811-14, IEEE Std 242, and IEEE Std 141.

The complexity and extent of coordinated power system protection depends on the type of buildings or facilities required, on the load demand of facilities, and on the quantity and types of facilities to be constructed. Facilities having a relatively-low power demand (e.g., 2500 kVA or less) generally require protection of: an incoming aerial distribution line or underground, medium-voltage feeder; low-voltage feeders to individual items of equipment, or to power distribution equipment, and branch circuits. More complex projects such as facilities with generating capacity, large motors, or larger load demands, will require more detailed and extensive coordinated power system protection.

Independent of the type or types of facilities or load demands, the coordinated power system protection will be based on: economics, simplicity, and the electrical power availability dictated by the Using Agency or Service, or by the functional use of the facilities or utilities; requirement to provide maximum power service with a minimum of power interruptions; and the operating speed of protective devices required to minimize damage to electrical components or items of equipment and to prevent injury to personnel and nuisance tripping.

Unless otherwise approved, a dc power source will be shown and specified to ensure proper closing and tripping of protective devices which require a reliable power source during outage of the normal alternating-current power source.

****

Analyses shall be prepared to demonstrate that the equipment selected and system constructed meet the contract requirements for ratings, coordination, and protection. They shall include a load flow analysis, a fault current analysis, and a protective device coordination study. The studies shall be performed by a registered professional engineer with demonstrated experience in power system coordination in the last [3] [_____] years. The Contractor shall provide a list of references complete with points of contact, addresses and telephone numbers. The selection of the engineer is subject to the approval of the Contracting Officer.

2.14.1 Scope of Analyses

The fault current analysis, and protective device coordination study shall begin at: [the source bus and extend down to system buses where fault availability is 10,000 amperes (symmetrical) for building/facility 600 volt level distribution buses.] [the source bus and extended through the secondary side of transformers for medium voltage distribution feeders.] [the source bus and extend through [outgoing breakers] [outgoing medium voltage feeders, down to the individual protective devices for medium voltage radial taps] [outgoing medium voltage feeders, through the secondary side of transformers] [as indicated] for main electric supply substations.] [the nearest upstream device in the existing source system and extend through the downstream devices at the load end.]

2.14.2   Determination of Facts

****
NOTE: Require the Contractor to obtain an available fault capacity at the power source or provide a fault capacity on which to base the analysis. Delete the unused option.
****

The time-current characteristics, features, and nameplate data for each existing protective device shall be determined and documented. [The Contractor shall coordinate with the [commercial power company] [_____] for fault current availability at the site.] [The Contractor shall utilize the fault current availability indicated as a basis for fault current studies.]

2.14.3   Single Line Diagram

A single line diagram shall be prepared to show the electrical system buses, devices, transformation points, and all sources of fault current (including generator and motor contributions). A fault-impedance diagram or a computer analysis diagram may be provided. Each bus, device or transformation point shall have a unique identifier. If a fault-impedance diagram is provided, impedance data shall be shown. Location of switches, breakers, and circuit interrupting devices shall be shown on the diagram together with available fault data, and the device interrupting rating.

2.14.4   Fault Current Analysis

2.14.4.1   Method

The fault current analysis shall be performed in accordance with methods described in IEEE Std 242, and IEEE Std 399.

2.14.4.2   Data

Actual data shall be utilized in fault calculations. Bus characteristics and transformer impedance shall be those proposed. Data shall be documented in the report.

2.14.4.3   Fault Current Availability

Balanced three-phase fault, bolted line-to-line fault, and line-to-ground fault current values shall be provided at each voltage transformation point and at each power distribution bus. The maximum and minimum values of fault available at each location shall be shown in tabular form on the diagram or in the report.

2.14.5   Coordination Study

The study shall demonstrate that the maximum possible degree of selectivity has been obtained between devices specified, consistent with protection of equipment and conductors from damage from overloads and fault conditions. The study shall include a description of the coordination of the protective devices in this project. A written narrative shall be provided describing: which devices may operate in the event of a fault at each bus; the logic used to arrive at device ratings and settings; situations where system coordination is not achievable due to device limitations (an analysis of any device curves which overlap); coordination between upstream and downstream devices; and relay settings. Recommendations to improve or enhance system reliability, and detail where such changes would involve additions or modifications to the contract and cost damages (addition or reduction) shall be provided. Composite coordination plots shall be provided on log-log graph paper.

2.14.6 Study report

a. The report shall include a narrative describing: the analyses performed; the bases and methods used; and the desired method of coordinated protection of the power system.

b. The study shall include descriptive and technical data for existing devices and new protective devices proposed. The data shall include manufacturers published data, nameplate data, and definition of the fixed or adjustable features of the existing or new protective devices.

c. The report shall document [utility company data including system voltages, fault MVA, system X/R ratio, time-current characteristic curves, current transformer ratios, and relay device numbers and settings;] [and] [existing power system data including time-current characteristic curves and protective device ratings and settings].

d. The report shall contain fully coordinated composite time-current characteristics curves for each bus in the system, as required to ensure coordinated power system protection between protective devices or equipment. The report shall include recommended ratings and settings of all protective devices in tabulated form.

e. The report shall provide the calculation performed for the analyses, including computer analysis programs utilized. The name of the software package, developer, and version number shall be provided.

PART 3 EXECUTION

3.1 VERIFICATION OF DIMENSIONS

After becoming familiar with details of the work, the Contractor shall verify dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing any work.

3.2 INSTALLATION

Protective devices shall be installed in accordance with the manufacturer's published instructions and in accordance with the requirements of NFPA 70 and IEEE C2.

3.3 FIELD TESTING

****

NOTE: Select types to suit project conditions and delete all others. Delete all paragraphs not applicable.

****

3.3.1 General

Field testing shall be performed in the presence of the Contracting Officer. The Contractor shall notify the Contracting Officer [_____] days prior to conducting tests. The Contractor shall furnish all materials, labor, and equipment necessary to conduct field tests. The Contractor shall perform all tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. The Contractor shall maintain a written record of all tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results.

3.3.2 Safety

The Contractor shall provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. The Contractor shall replace any devices or equipment which are damaged due to improper test procedures or handling.

3.3.3 Molded-Case Circuit Breakers

Circuit breakers shall be visually inspected, operated manually, and connections checked for tightness. Current ratings shall be verified and adjustable settings incorporated in accordance with the coordination study.

3.3.4 Power Circuit Breakers

3.3.4.1 General

The Contractor shall visually inspect the circuit breaker and operate the circuit breaker manually; adjust and clean primary contacts in accordance with manufacturer's published instructions; check tolerances and clearances; check for proper lubrication; and ensure that all connections are tight. For electrically operated circuit breakers, the Contractor shall verify operating voltages on closing and tripping coils. The Contractor shall verify fuse ratings in control circuits; electrically operate the breaker, where applicable; and implement settings in accordance with the coordination study.

3.3.4.2 Power Circuit Breaker Tests

****

NOTE: List specific breakers to be tested. Delete entirely if test not required.

****

The following power circuit breakers shall be tested in accordance with ANSI C37.50.

a. [_____]

b. [_____]

c. [_____]

3.3.5 Protective Relays

Protective relays shall be visually and mechanically inspected, adjusted, tested, and calibrated in accordance with the manufacturer's published instructions. Tests shall include pick-up, timing, contact action, restraint, and other aspects necessary to ensure proper calibration and operation. Relay settings shall be implemented in accordance with the coordination study. Relay contacts shall be manually or electrically operated to verify that the proper breakers and alarms initiate. [Relaying current transformers shall be field tested in accordance with IEEE C57.13.]

-- End of Section --