UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2025
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DIVISION 26 - ELECTRICAL

SECTION 26 05 73

POWER SYSTEM STUDIES

08/23

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USACE / NAVFAC / AFCEC **UFGS-26 05 73 (August 2023)**

Preparing Activity: USACE **Superseding**
UFGS-26 28 01.00 10 (August 2021)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

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SECTION 26 05 73

POWER SYSTEM STUDIES
08/23

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NOTE: This guide specification covers the requirements for power system studies typical for incident energy analysis to support an arc flash risk assessment.

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

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

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

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PART 1 GENERAL

1.1 REFERENCES

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

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of

the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

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

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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 1584	(2018; E 2019) Guide for Performing Arc-Flash Hazard Calculations
IEEE 1584.1	(2022) Guide for the Specification of Scope and Deliverable Requirements for an Arc-Flash Hazard Calculation Study
IEEE 3002.2	(2018) Recommended Practice for Conducting Load-Flow Studies and Analysis of Industrial and Commercial Power Systems
IEEE 3002.3	(2018) Recommended Practice for Conducting Short-Circuit Studies and Analysis of Industrial and Commercial Power Systems
IEEE C2	(2023) National Electrical Safety Code

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70E	(2024) Standard for Electrical Safety in the Workplace

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-560-01	(2017; with Change 3, 2023) Operation and Maintenance: Electrical Safety

1.2 SYSTEM DESCRIPTION

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

Coordinate with Section 26 11 14.00 10 MAIN ELECTRIC SUPPLY STATION AND SUBSTATION; Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION; Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION; Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM; and Section 26 08 00 APPARATUS INSPECTION AND TESTING.

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

1.3 SUBMITTALS

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NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

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

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

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

SD-01 Preconstruction Submittals

Field Examination Plan; G, [_____]

Arc Flash Label Formats; G, [_____]

SD-06 Test Reports

Field Examination

SD-07 Certificates

System Analyzer; G, [_____]

SD-11 Closeout Submittals

Model Files; G, [_____]

Load Flow Study; G, [_____]

Fault Current Study; G, [_____]

System Coordination Study; G, [_____]

Arc Flash Hazard Study; G, [_____]

1.4 QUALITY ASSURANCE

1.4.1 System Analyzer

The System Analyzer must perform the power system studies. The System Analyzer must be a registered professional electrical engineer with a minimum of [3] [_____] years of experience with power system studies. Include a list of three comparable jobs performed by the System Analyzer with specific names and telephone numbers for reference. Include the license number and state of the registered Professional Engineer.

1.4.2 System Verifier

The System Verifier may inspect and record settings, markings, and otherwise document the existing equipment. The System Verifier may also place appropriate hazard labels on equipment. The System Verifier must not make any calibrations or adjustments or place equipment into service. When working with energized equipment, the system verifier must be a Qualified Person per NFPA 70E or working under the direct supervision of a Qualified Person. [The System Verifier may communicate with the system owner to determine if the equipment within the studied system has received maintenance and testing in accordance with NETA MTS or NFPA 70B.]

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 FIELD EXAMINATION

For each pre- and post-study inspection, submit a field examination plan identifying which facilities must be examined to complete the required work. Include a complete information verification procedure, where Qualified Personnel will be required, PPE requirements for "live" equipment examinations, and equipment to be used within the limited approach boundary of the equipment.

3.1.1 General

Perform field inspections of the site and equipment before the first study and after the last study to determine the state and settings of the equipment and to verify the final settings agree with the studies. [Perform the post-study inspection(s) after changing settings, after performing acceptance tests, and before placing equipment in service.][The post-study inspection may be performed by the testing organization approved in 26 08 00 APPARATUS INSPECTION AND TESTING.]

Schedule the field examination by the System Verifier with the Contracting Officer at least [10][_____] business days before conducting examination. Furnish all materials, labor, and equipment necessary to conduct the examination. Maintain a written record of the all equipment examined, equipment location, equipment ratings, settings, personnel involved, and the date the examination was performed. Submit the written record of each field examination.

3.1.2 Safety

Where examination of the equipment requires energized equipment to be opened, provide a Qualified Person to directly supervising any non-Qualified Person within the hazard area. Use PPE, protective barriers, danger signs and other safety devices to protect and warn personnel in the vicinity of "live" equipment being examined.

[3.1.3 Application of Arc Flash Labels

Install arc flash warning labels using Qualified Personnel as necessary after the setting and inspection is complete. For new or modified equipment, install labels before the equipment is energized for the first time after installation/modification or setting changes. Schedule the label placement with the Contracting Officer at least [5][_____] business days before label placement. Furnish all materials, labor, and equipment necessary to place the labels. Maintain a written record of the all equipment that received labels, personnel involved, and the date labels were placed.

]3.2 POWER SYSTEM STUDIES

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NOTE: The designer of record will be responsible for showing and specifying the requirements for fuses, circuit breakers, protective relays, or other protective devices associated with the project.

The complexity and extent of power system studies depends on the type facilities, on the load demand of facilities, and on the quantity of facilities to be constructed. Facilities having a relatively-low power demand (e.g., 500 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 studies.

Choose the first paragraph for construction or modification of equipment. Choose the second paragraph for periodic study of existing equipment.

****

[Perform power system studies to demonstrate that the equipment selected and system constructed meet the contract requirements for fault current and interrupt ratings, coordination, protection, and Arc Flash Hazard. Submit reports of the studies along with protective device equipment

submittals. Apply Arc Flash Hazard labels to equipment after the studies are approved. Update and resubmit the studies after any changes to the equipment or systems which may affect the study results, and re-apply Arc Flash Hazard labels to equipment after the resubmitted studies are approved. The Government is not responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices [or labels]ordered and/or procured before approval of the study.]

[Perform power system studies to demonstrate the system operation with regard to ratings, coordination, protection, and Arc Flash Hazard.]

3.2.1 Scope of Studies

****
NOTE: Provide a description of the scope of the power system studies.
****

[_____]

The scope of the studies must begin at [the source bus and extend down to system buses where fault current availability is 10,000 amperes or less (symmetrical) and at most 600 volts for facility-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.][the utility service entrance of a building and extend down to load buses/panels where the fault current is 2,000 amperes or less (symmetrical) for distribution buses nominally operating at 208 volt AC and above.][For DC system studies, include all DC systems nominally operating at 50 volts and above with fault currents greater than 1,000 amperes.][_____]

The "source bus" is the source of energy for system being analyzed. This may be the energy feed from a utility, the first bus upstream of the work, generators within the work or upstream of the work, or any other source capable of contributing significant energy into the system being analyzed.

In the systems model for the studies, incorporate all existing and new equipment within the scope of the studies. Incorporate any additional sources or load equipment necessary to accurately model the system's performance.

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NOTE: For simple radial power systems with one source and no alternate power source such as a generator or backup feed, there is usually only one system mode of operation (scenario) to be analyzed. Systems with multiple modes of operation including generators may have the load currents, fault currents, and arc flash energies affected by which sources are in services. Loops in the feeder/distribution system that are opened or closed may affect load currents, faults, currents, and arc

flash energies. The multiple modes of operation (scenarios) must be analyzed to determine which modes are most stressful to the equipment and produce the greatest arc flash hazard.

****

Where multiple sources of power may be in service in various combinations or where electrical loops are in the system, incorporate into the studies all the modes of operation to evaluate the impact of the modes of operation on the system.[The primary modes of operation are listed below.

1. [_____]

2. [_____]]

3.2.2 Determination of Facts

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

Where fault current is not available, the System Analyzer should used their technical knowledge, experience, and system information to make a reasonable estimate of the fault capacity. Such an estimate may produces results that are less accurate than using the known fault capacity.

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Determine and document the time-current characteristics, features, ratings, ampacities, and nameplate data for each existing protective device, electrical equipment, and feeder cables. [Obtain the available fault current from the [owner of the source bus][_____].] [Utilize the indicated available fault current.] [For multiple modes of operation, use the mode with available fault current that produces the greatest incident energies in the arc flash hazard study.]

[Utilize field-verified data in the power system studies. Document the field-verified data in the report.]

3.2.3 Single Line Diagram

Provide a single line diagram showing the electrical system buses, devices, transformation points, and all sources of load current and fault current, including generator and motor contributions. Provide a diagram from the system model. Each bus, device or transformation point must have a unique identifier. Show the location of switches, breakers, and circuit interrupting devices on the diagram together with available fault data, and the device interrupting rating.

The naming of existing components within the system model and single line diagram must match existing installed equipment names. The naming of new components within the system model and single line diagram must use unique identifiers and be coordinated with the Government.

3.2.4 Load Flow Study

Perform the load flow study in accordance with IEEE 3002.2 to identify initital steady-state conditions for the fault current study. For each operating scenario, provide load flow results on the diagram or in the report. Show or describe the loading factors and assumptions used in each operating mode.

3.2.5 Fault Current Study

Use the results of the load flow study to perform the fault current study in accordance with IEEE 3002.3. Provide balanced three-phase fault, bolted line-to-line fault, and single line-to-ground fault current values at each voltage transformation point and at each power distribution bus. For each location, show in tabular form on the diagram or in the report the maximum and minimum available fault currents of all modes of operation for that location.

****

NOTE: For some systems the fault current or system impedance may not be available. In some cases the utility may only provide a provide a fault current on the transformer secondary based on an infinite bus on the primary, a withstand current rating, an overcurrent protection kAIC or SCCR rating, transformer nameplate data. For these situations, the source contributions need to be carefully estimated to avoid having currents that are too high or too low. Poor estimates can lead to errors in under or over specifying equipment capabilities, coordination issues, and under or over stating Arc Flash Hazards.

NEMA AB-5, NEMA ABP-1, IEEE 946, IEEE 3004.3, IEEE 3004.5 and IEEE 3004.11 may provide assistance in the coordination of overcurrent devices.

****

Where the available fault current at the source bus is not available, describe how the fault contribution from the source bus was determined and why this method is reasonable for the study.

3.2.6 System Coordination Study

Use the results of the load flow study and fault current study. For normal modes of operation, demonstrate that selectivity has been obtained between the devices within the scope of the project. Demonstrate the equipment, machines, and conductors are protected from damage from overloads and fault conditions. Include a description of the coordination of the protective devices in this project. Provide a written narrative 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; coordination between upstream and downstream devices; and relay settings. Provide 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). Provide composite coordination plots on a log-log scale. Where recommendations are provided

to improve or enhance system reliability, provide separate coordination plots on log-log scale showing the system coordination before and after the implementation of the recommendations.[Where coordination has been adjusted to lower arc flash values, include a discussion of the change and the impact on the system within the report.]

3.2.7 Arc Flash Hazard Study

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NOTE: Combinations of multiple sources (including generators) and/or loops in the feeder/distribution system can affect the available incident energy. The system owner should be consulted to determine what incident energy thresholds are acceptable and do not need recommendations for reducing the incident energy.

****

Perform the arc flash hazard study in accordance with IEEE 1584.1. Utilize the data from the fault current study to determine the worst case incident energy per IEEE 1584[, IEEE C2,] and OSHA 29 CFR 1910.269 Appendix E. Use identified modes of operation to determine the worst case arc flash energy. If not included in another study, include a description of the devices and device settings for the operating modes that provided the highest arc flash energy. [The use of a "maintenance switch" to temporarily reduce the Arc Flash incident energy for maintenance work is acceptable.][Where the adjusting the coordination of devices to obtain lower arc flash values, include a discussion of the change and the impact on the system within the report.] [Where the arc flash energies exceed [1.2 cal/cm^2][4 cal/cm^2][8 cal/cm^2] provide recommendations to reduce the arc flash energy to [1.2 cal/cm^2][4 cal/cm^2]].[

Where the AC system voltage is 208 volts or less with an available short-circuit current less than 2000 A, an arc flash hazard study is not required.]

3.2.8 Study report(s)

a. Include a narrative describing the studies performed; the bases and methods used; and the desired method of coordinated protection of the power system.

b. Include descriptive and technical data for existing devices and new protective devices proposed. Include manufacturers published data, nameplate data, and definition of the fixed or adjustable features of the existing or new protective devices. For existing devices, included statements on the condition of the equipment based upon field inspections and owner's statements and reports.

c. 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;][generator resistance and reactance values, and time constants;] [and] [existing power system data including time-current characteristic curves and protective device ratings and settings]. Identify all assumptions about the protection devices, equipment, and system where data was not available.

d. For each bus in the system, provide fully coordinated composite time-current characteristics (TCC) curves as required to ensure coordinated power system protection between protective devices and equipment. In a tabular format, provide [existing and]recommended ratings and settings of all protective devices.

e. Provide an arc flash study report in accordance with IEEE 1584.1.

f. Provide the calculations performed for the studies, including computer programs utilized. Provide the name of the software package, developer, and version number.

[
g. The System Analyzer must stamp the study reports.
]

3.2.9 Arc Flash Labels

Provide arc flash warning labels on electrical equipment likely to require examination, servicing, or maintenance while energized. Typical types of equipment include pad-mounted transformers, switchgear, switchboards, panelboards, disconnect switches, industrial control panels, meter socket enclosures, and motor control centers that are in other than dwelling occupancies. The arc flash label naming must match the naming used in the system modeling and the single line diagram.

Comply with the label requirements specified in UFC 3-560-01NFPA 70E. Obtain approval of arc flash label formats before printing.

a. Provide a [3.5 inch x 5 inch to 4 inch x 6 inch][____] thermal transfer type label of high adhesion polyester for each location device analyzed. The label must remain in place and be legible for at least 5 years in the installed environment.

b. Labels must be machine printed with no field markings. Provide arc flash labels in the following manner. All labels must be based on implemented overcurrent devices and settings.

1. Provide at least one arc flash label for each 480 volt and 208 volt panelboards.

2. Provide at least one arc flash label for each low voltage (less than 1000 V) switchboard.

3. Where the equipment construction has different hazards levels in different areas, provide [a label for each compartment, cubicle, or section separated by barriers][a single label representing the worst case hazard for all branch circuits and a separate unique label for the compartment containing the main protective device. On the worst case label, indicate which branch circuit compartments have the worst case hazard.]

c. Use the worst case hazard of all operating scenarios unless mitigation procedures are used. If mitigation procedures are used, explain the procedures on the label.

3.3 MODELING

Develop a software model of the electrical system identified in the scope of the studies. Use the latest version of [SKM PowerTools(TM)][EasyPower(TM)][ETAP(TM)][_____]. Develop the model with

accurate, verified information. Model existing electrical equipment, machines, devices, and conductors directly connected to, altered by, or otherwise affected by the work. This includes, but is not limited to generators, transformers, switchgear, switchboards, panelboards, motor control centers, motors, voltage regulators, tap changers, protective relays, circuit breakers, switches, fuses, conductors, capacitors, reactors, grounding system, and control equipment.

Provide the final model files in their native editable formats for future use by the Government. Include device information for devices not in the software vendor's standard distribution.

-- End of Section --