

CHAPTER 8
ELECTRICAL

8.1	GENERAL	3
8.2	REQUEST FOR PROPOSAL DEVELOPMENT	3
8.3	DESIGN DEVELOPMENT	3
8.3.1	CONCEPT (30%) DESIGN SUBMITTAL REQUIREMENTS	3
8.3.1.1	<i>Concept Design Analysis</i>	3
8.3.1.1.1	<i>Design Criteria</i>	3
8.3.1.1.2	<i>Exterior Electrical Distribution System</i>	3
8.3.1.1.3	<i>Interior Electrical Distribution Systems</i>	4
8.3.1.1.3.1	<i>Service Entrance</i>	4
8.3.1.1.3.2	<i>Equipment Data</i>	4
8.3.1.1.3.3	<i>Lighting</i>	4
8.3.1.1.3.4	<i>Conduit and wiring</i>	5
8.3.1.1.3.5	<i>Special Items</i>	5
8.3.1.1.3.6	<i>Hazard Classes</i>	5
8.3.1.1.4	<i>Communications and CATV System</i>	5
8.3.1.1.5	<i>Grounding</i>	5
8.3.1.1.6	<i>Metering</i>	5
8.3.1.1.7	<i>Fire Alarm and Mass Notification Systems</i>	5
8.3.1.1.8	<i>Special Systems</i>	6
8.3.1.1.9	<i>Field Trip Report</i>	6
8.3.1.1.10	<i>Miscellaneous Information</i>	6
8.3.1.2	<i>Concept Drawings</i>	6
8.3.1.2.1	<i>Exterior Electrical System</i>	6
8.3.1.2.2	<i>Characteristics</i>	6
8.3.1.2.3	<i>Capacity</i>	6
8.3.1.2.4	<i>Communications</i>	7
8.3.1.3	<i>Concept Specifications</i>	7
8.3.2	INTERIM (60%) DESIGN SUBMITTAL	7
8.3.2.1	<i>Interim Design Analysis</i>	7
8.3.2.1.1	<i>Exterior Electrical Distribution</i>	7
8.3.2.1.2	<i>Interior Electrical and Communications Systems</i>	7
8.3.2.1.3	<i>Lighting</i>	7
8.3.2.1.4	<i>Fire Alarm and Mass Notification System</i>	7
8.3.2.2	<i>Interim Drawings</i>	7
8.3.2.2.1	<i>Exterior Electrical Drawings</i>	7
8.3.2.2.1	<i>Interior Drawings</i>	8
8.3.2.3	<i>Interim Specifications</i>	8
8.3.3	FINAL (90%) DESIGN SUBMITTAL	8
8.3.3.1	<i>Final Design Analysis</i>	8
8.3.3.2	<i>Final Calculations</i>	8
8.3.3.3	<i>Final Drawings</i>	9
8.3.3.3.1	<i>Exterior Electrical Systems</i>	9
8.3.3.3.2	<i>Interior Electrical Systems</i>	9
8.3.3.3.3	<i>Checking</i>	10
8.3.3.4	<i>Final Specifications</i>	10
8.3.4	CORRECTED FINAL (100%) DESIGN SUBMITTAL.....	10
8.4	TECHNICAL REQUIREMENTS	10
8.4.1	APPLICABLE PUBLICATIONS	10
8.4.2	BASIS OF DESIGN	11
8.4.3	SYSTEM SELECTION	11
8.4.4	LIGHTING SYSTEM.....	11
8.4.5	SURGE PROTECTIVE DEVICE	11
8.4.6	LIGHTNING PROTECTION SYSTEM.....	11

ELECTRICAL

8.4.8 COMMUNICATIONS 11
8.4.9 PRIMARY ELECTRICAL SYSTEM..... 11

8.1 GENERAL

This chapter gives general guidance for the preparation of drawings, specifications, and design analyses as related to electrical aspects of military construction projects. The purpose is to provide guidance for preparing accurate and complete electrical designs that are cost effective, energy efficient and inherently reliable and safe. The design of electrical systems shall be in accordance with UFC 3-501-01, Electrical Engineering and applicable publications.

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8.2 REQUEST FOR PROPOSAL DEVELOPMENT

The Request for Proposal shall contain adequate information for the design-build contractor to develop a bid package. Information shall include the primary source of power, characteristics of the power supply to the site, or portion involved and the communications point of connection and requirements. Required demolition work, available power, the source, location, and adequacy of the primary supply should be included. Indicate total connected load and resulting KVA demand load by applying demand (state operating assumptions) and diversity factors based on square footage of building.

The Request of the Proposal should also identify all known, and any potential, systems and constraints that apply to the project. Systems might include fire alarm, mass notification, IDS, CCTV, secure areas, SIPRNET, data, telephone, emergency generator, UPS, and cyber security. Constraints might include points of connection for existing systems (e.g. – fiber-optic, telephone, primary electrical); use of overhead or underground distribution; customer-defined requirements or constraints for specific installations; target lighting levels; renovation issues, e.g. adequacy of existing interior electrical distribution system and communications service; potential hazardous/classified (NEC) areas.

8.3 DESIGN DEVELOPMENT

8.3.1 CONCEPT (30%) DESIGN SUBMITTAL REQUIREMENTS

8.3.1.1 Concept Design Analysis

The electrical design shall include a Design Analysis that shall include the following:

8.3.1.1.1 Design Criteria

Include a list that will be used for all electrical systems, including communications systems.

8.3.1.1.2 Exterior Electrical Distribution System

- a. Primary Source and Point of Connection: Contact the DPW/BCE to obtain information relative to the adequacy of the primary supply at the point of takeoff. If the primary source is inadequate, state measures proposed to correct the deficiency in the design. Verify a point of connection with the installation. If the electrical utility on the installation is privatized, delineate what the contractor's and the utility's responsibilities will be.
- b. Primary Service: Indicate the primary distribution voltage and whether this service will be run aerial or underground and state the basis for this selection.
- c. Secondary Service: Provide electrical characteristics of power supply from the service point to the main service equipment (voltage, phase, number and size of conductors). Indicate whether this service will be run aerial or underground. State the basis for selection of distribution voltage i.e., 480Y/277V versus 208Y/120V.
- d. Conductors: State the type of conductor, such as copper or aluminum, and where they are proposed to be used. Indicate for both the primary and secondary service.

- e. Connected Load: Narrate assumptions and conclusions related to the estimated total connected load and estimated kVA demand load. Indicate type, number, and kVA capacity of transformer installation proposed. State the primary and secondary connection of transformers (i.e. 12470 to 480Y/277 volts, delta-wye).
- f. Exterior Lighting: Provide a statement describing street lighting, security, parking lot lighting, or sidewalk lighting requirements. Types of fixtures, pole type, pole heights, and proposed lighting intensities are to be included. Describe whether the lighting will be on photocell or time clock. Coordinate with the installation the type of light fixtures, poles, finishes etc. to be specified.
- g. Cathodic Protection: Where cathodic protection is required by the project criteria or other instructions provide field measurements and recommendations for the need and type of system to be employed.
- h. Lightning Protection: Perform a Lightning Hazard Risk Assessment per NFPA 780 to determine if lightning protection is recommended. Recommendation will be based on this assessment. If system is required or recommended describe it. State if LPS is not required or recommended.
- i. Grounding: Describe grounding system to be installed, if required. If a counterpoise, grid, etc., is to be used, state the standards to be used in design and calculations.
- j. Communication System: Describe the telephone system requirements. Indicate whether cables shall be run aerial or underground and provide the point of connection (POC) with the existing installation infrastructure. Indicate the type and size of cable. Provide all instructions received from the Network Enterprise Center (NEC) (Army) or the Base Communication Office (BCO) (Air Force).
Describe the data system requirement - Include the type of cable and provide support for whether the type of cable is fiber optic or copper or both. Provide the point of connection and location of switch, and all instructions received from the NEC (Army) or the BCO (Air Force).
- k. Cable Television System: Describe the cable television system if required. Indicate where the main equipment will be located and include a description of the infrastructure required. State the installation's existing system and what will be required to interface with the existing system. Note what entity will make the final terminations.
- l. The requirement for a generator is authorized and will be noted as a line item on the 1391. If a generator is authorized, provide requirements, such as purpose, emergency back-up load, length of time back-up power is required, type of fuel.
- m. Describe type of renewable energy when required.

8.3.1.1.3 Interior Electrical Distribution Systems

Indicate electrical characteristics (phases, voltage and number of wires) of electrical system. Indicate the type and phase of all transformers and where they will be located. For renovation projects, determine the adequacy of existing distribution system and indicate plan of action if upgrade is required.

8.3.1.1.3.1 Service Entrance

- a. Describe service entrance and service equipment selected.
- b. Provide an estimate of total connected load (kVA) and the resulting demand load (kVA), transformer size, and service size.

8.3.1.1.3.2 Equipment Data

Describe basic characteristics of panelboards, protective devices, switchboard or switchgear, motor control center, generator, UPS or other major equipment to be provided.

8.3.1.1.3.3 Lighting

- a. Standard Lighting: Provide a brief description of the lighting system(s) to be used for

major areas. Include a list of lighting parameters, for each anticipated room type along with a proposed fixture type. List should include room type, target lighting intensity, type of fixture, voltage, wattage, mounting (wall or ceiling), mounting height, and basis of design such as I.E.S., etc. Include description of lighting control, such as the use of day lighting, occupancy sensors, etc.

- b. Emergency and Exit Lighting: Provide a brief description of the emergency and exit lighting system. Include the type of fixtures and provide foot-candle values for the systems.

8.3.1.1.3.4 Conduit and wiring

State the type of wiring system, such as rigid conduit, intermediate metallic conduit, electrical metallic tubing, nonmetallic sheathed cable, or cable tray, etc., and where it will be used.

8.3.1.1.3.5 Special Items

Provide paragraph describing proposed addition and alterations of special items of design, such as, specialized equipment, special receptacles, physically disabled and seismic requirements, etc., include description and location of special power outlets and circuits (volts, phase, and amps). Reference pertinent NEMA or any recognized standards to identify the type receptacles selected. Include documentation of the source of the criteria.

8.3.1.1.3.6 Hazard Classes

Define any hazardous area by class, division and group as defined in the National Electrical Code (NFPA 70) and indicate type of equipment proposed for use in the area.

8.3.1.1.4 Communications and CATV System

- a. Describe the telephone system requirements including the type system, the type of instruments and the size of the installation including stations, trunk size, connection to and location of switch, and all instructions received from the Network Enterprise Command (NEC) (Army) or the Base Communication Office (BCO) (Air Force).
- b. Describe the data system requirement including the type of cable, type of instruments, and the size of the installation, including stations, trunk size, connection to and location of switch, and all instructions received from NEC (Army) or BCO (Air Force). Indicate if SIPRNET is required.
- c. Describe the cable television system if required. Indicate where the main equipment will be located and include a description of the infrastructure required. State the installation's existing system and what will be required to interface with the existing system. Note what entity will make the final terminations.

8.3.1.1.5 Grounding

Describe grounding system to be installed.

8.3.1.1.6 Metering

Describe electrical metering equipment to be provided and whether the outputs are to be transmitted to the Base EMCS system, as applicable, and the method of transmission.

8.3.1.1.7 Fire Alarm and Mass Notification Systems

- a. Describe type of fire detection and notification system, including mass notification. Include a list of required devices. Include any compatibility issues that may occur when connecting to the installation system.

If an existing base fire alarm system is being expanded, the construction contractor does not normally supply the central station receiver module. However, any equipment supplied must be fully compatible with the existing system equipment, and if a receiver module is supplied it must be physically as well as electrically compatible. Determine the make and model of existing equipment and include sufficient information in the

specifications and plans to insure compatibility of the completed system.

Where installations have central fire alarm receiving stations that are dependent upon a unique coding scheme, transmission to the central station fire alarm status panel at each project facility may be by a transmitter unique to the system and will, therefore, require that proprietary equipment be specified. Consult with the PE/A before the Concept Design to ensure that proper procedures to specify this equipment are available.

8.3.1.1.8 Special Systems

Describe any additional electrical requirements such as public address, access control, intrusion detection, CCTV, or electronics requirements.

- a. Describe public address system and where it is required.
- b. Describe access control system.
- c. Describe the intrusion detection system and include CCTV requirements. Unless specifically funded on the project's DD Form 1391, only conduit and boxes shall be provided for Intrusion Detection Systems. Equipment to be connected to the conduit and box layout will be provided by the Using Activity. Design information on conduit and box locations and sizes will be furnished by the Using Activity.
- d. Describe any special security system infrastructure that will be required by the end user. Indicate conduit type and any specialized outlet boxes required.
- e. Describe any special areas, such as Secure Areas (i.e, Sensitive Compartmented Facility, TEMPEST requirements.)

8.3.1.1.9 Cybersecurity

Identify the System Owner (SO) and Authorizing Official (AO), identify systems affected, determine the Confidentiality, Integrity, and Availability (C-I-A) impact levels, and provide the Control Correlation Index (CCI) list for each system.

8.3.1.1.10 Field Trip Report

A field trip report should be furnished. This report should contain records of meetings held with facility personnel, including participant lists. Any agreements or understandings reached with facility personnel, or any unforeseen site/building conditions, should be documented in the report.

8.3.1.1.11 Miscellaneous Information

Additional information or material required to complete the design shall be listed, or a statement shall be made that none is needed.

8.3.1.2 Concept Drawings

8.3.1.2.1 Exterior Electrical System

Provide a separate electrical site plan indicating all existing and proposed support utility lines and equipment required to serve the project including electrical power lines, communication cables, cable television cable, all roads and driveways, parking areas, and other items necessary for functional and operating adequacy. Indicate the extent of any demolition to be done. If extensive, provide separate drawings with independent legend for new work.

8.3.1.2.2 Characteristics

Provide electrical characteristics (voltage and phase) for the primary and secondary lines at the point of delivery and/or any extension. Indicate characteristics and standards of design for aerial or underground lines.

8.3.1.2.3 Capacity

Indicate the type, number, location, kVA capacity, primary and secondary voltage of the transformer installation proposed. Identify the primary and secondary connections of the transformer(s).

8.3.1.2.4 Communications

Identify any existing and new communications service connections, both aerial and underground. Indicate characteristics and standards of design for aerial or underground communication lines.

8.3.1.3 Concept Specifications

Not applicable with this submittal.

8.3.2 INTERIM (60%) DESIGN SUBMITTAL

8.3.2.1 Interim Design Analysis

The Design Analysis shall be an entirely updated analysis (not amendments to 30% submittal) to permit verification that the design complies with the criteria furnished and the approved 30% design phase and approved review comments. Information required at the 30% design phase shall be included with more detail.

8.3.2.1.1 Exterior Electrical Distribution

Determine and state the estimated primary and secondary wire sizes, transformer sizes, communication cable sizes (copper and fiber optic cable), type of parking lot and street lighting systems.

8.3.2.1.2 Interior Electrical and Communications Systems

Determine estimated demand loads. Provide a breakdown, by category, of the estimated loads (kVA). Include lighting, convenience outlet, mechanical equipment (if available), special operating equipment, user equipment, and miscellaneous load categories. Provide estimated sizes of feeders, service entrance, and transformers. Individual circuit load tabulations and interior voltage drop calculations are not required for this submittal.

8.3.2.1.3 Lighting

Include catalog cut sheets of light fixtures proposed. Provide photometric calculations for each room.

8.3.2.1.4 Fire Alarm and Mass Notification System

Include fire alarm and mass notification analysis stating the basis behind the equipment chosen.

8.3.2.2 Interim Drawings

8.3.2.2.1 Exterior Electrical Drawings

Exterior electrical, cable television, and communication layout plans are required and must be separate from water, sewage, and other utility plans. Show other new or existing utilities only as required to prevent conflicts with the electrical work. Indicate separation between the different utility systems and include depth requirements.

- a. Complete all exterior electrical plans with poles, manholes, and other pertinent components indicated. Include transformer location, kVA, voltage and phase characteristics and conductor type, size and number.
- b. Indicate location and type (aerial or underground) of all new communications, cable television, primary and secondary lines, service drops, and transformers. Show conductor sizes and material types. If cables are run underground, indicate whether concrete encased or direct buried.
- c. Indicate poles, manholes, and equipment to be relocated or removed. Clearances from buildings shall be IAW the National Electric Safety Code.
- d. Indicate new location of any relocated electrical items.
- e. Show accurate location and sizes of existing lines including poles and transformers from which power is to be obtained.
- f. Provide layout of lighting for parking lots, sidewalks and streets.
- g. On large projects where underground systems are used, furnish prints of the site showing

communication service connection points of each building, manholes and final connection to the existing system.

8.3.2.2.1 Interior Drawings

The interior electrical drawings shall include the designation of all rooms and work areas by name and room number as shown on the architectural or other drawings.

- a. Show service drop connection location.
- b. Panelboards, motor control center, switchboard, switchgear equipment and all utilization equipment shall be located. Dedicated electrical space shall be provided around and above panelboards, switchboards, transfer switchboards, transformers, transfer switches, motor control centers and similar major items of electrical equipment. Define this space as stated in NEC.
- c. Show the location and type of lighting fixtures to be installed in each area.
- d. Complete lighting fixture schedule shall be included.
- e. All demolitions and relocations, if any, must be shown. If demolitions and relocations are extensive, separate plans are required.
- f. A complete symbol legend for all devices or equipment shall be shown on the plans.
- g. Show the locations of receptacles, communication outlets, mechanical equipment, etc.
- h. Include special features such as under floor raceways, bus duct, communication facilities, kitchen layout, additional security requirements etc.
- i. Interior wiring need not be shown on 65% electrical plans.
- j. Define the limits of all hazardous areas and indicate the Class, Division, and Group, which applies per the NEC.
- k. Show areas/rooms of coverage requiring fire alarm detection and notification. Show locations of control panels, annunciator panels, and mass notification system devices, on the floor plans. Provide fire alarm and mass notification system riser diagram and matrix. Include in the riser diagram duct smoke detectors, elevator systems, kitchen hood suppression systems, sprinkler tamper and flow switches.
- l. Include power system riser diagram.

8.3.2.3 Interim Specifications

Provide final outline specifications. Editing of the specifications is not required. Where no UFGS sections or standard specification sections are provided, prepare an outline of the new specification section from available criteria and instructions giving all pertinent material characteristics.

8.3.3 FINAL (90%) DESIGN SUBMITTAL

8.3.3.1 Final Design Analysis

- a. Submit an entirely updated design analysis (not amendments to previously submitted design analysis) to support this submittal. Implement previous submittal approved comments.
- b. Trade names are not allowed on the contract plans and specifications; however, for lighting fixtures and other equipment such as motor control centers, switch gear, bus duct, transformers (where special features are required), special receptacles, etc. Include the current manufacturer and catalog number of the equipment in the Design Analysis.
- c. Provide "Engineering Considerations for the Field Personnel" as necessary for electrical aspects of the construction. Considerations should address special inspections or tests for systems, unusual features of the systems, or other information that could mitigate risk during construction.

8.3.3.2 Final Calculations

Provide design calculations and supporting documentation to support design considerations. Calculations shall be computed and checked by separate individuals, one of which must be a registered electrical engineer. Indicate the names or initial of these individuals on the page or

insert carrying the calculations. Supporting documentation shall be clear, and formulas and references shall be identified. Assumptions and conclusions shall be explained, and cross-referencing shall be clear. When a commercial computer program is used, name the program. Ensure that inputs and outputs, of all computer programs, are labeled as appropriate for the project. Include calculations and data for the following in the analysis:

- a. Lighting calculations: Provide calculations for standard and emergency/egress lighting. Calculations shall verify that the target lighting levels are achieved and not significantly exceeded.
- b. Short-circuit calculations.
- c. Protective device-time current coordination study.
- d. Arc flash analysis.
- e. Voltage drop calculations.
- f. Existing loading data where connections are made to existing transformers or load centers including method of determining the availability of sufficient capacity for the additional loads.
- g. Load Analysis: Include calculations of all connected loads, demand factors, and demand loads by circuit number for each panel and switchboard. Show amp-interrupting circuit ratings for each switchboard and panelboard.
- h. Calculations for cathodic protection, if applicable.
- i. Generator sizing calculations.
- j. Lighting Hazard Risk Assessment per NFPA 780 requirements.

8.3.3.3 Final Drawings

The final drawings are an extension of the approved 60% drawings. Incorporate any previous approved comments.

8.3.3.3.1 Exterior Electrical Systems

Include all plans and details for final package on drawings. Include any lighting pole configurations, power pole configurations, duct bank details, pole foundation details, manhole details, switch details, conduit stub-up details, pad mount equipment and grounding details, etc.

8.3.3.3.2 Interior Electrical Systems.

- a. Details: Include all details for final package on drawings. For congested areas that might interfere with various electrical systems, cable trays, piping, ducts, etc., thoroughly detail by expanded scale drawings. At a minimum include enlarged plan views of the communications and electrical rooms, and elevation views of switchboards/switchgear and communication racks.
- b. Lighting Systems: Include wiring details, location of emergency lights, and exit lights. Provide switch locations, details of control systems, light fixture schedule and light fixture details.
- c. Power Systems: Include locations and details for any specialized outlets. Include wiring and conduit details for all electrical equipment. Provide a detailed one-line diagram indicating all required information.
- d. Riser Diagrams: Provide complete riser diagrams for fire detection and alarm and mass notification system, intrusion detection conduit system, cable television system, public address system, telephone/communication system, etc. Riser should show the location of the various components and interconnections with other systems such as elevator, HVAC and hood fire suppression connections to fire alarm panels, etc. Conduit and wire size and the quantity of wire should not be shown on the riser diagrams, for the fire protection system, since these vary between manufacturers and the minimum size requirements are in the UFGS specifications.
- e. Communication Systems: Show an interior telephone and data system consisting of the conduits, cable trays, cabinets, outlets, etc. as required by criteria.
- f. Electrical requirements for mechanical equipment: Show locations, electrical characteristics, kW (if applicable) of electrically driven equipment on the drawings.

- g. Panel Schedules: Provide detailed panel schedules indicating phase loads, panel rating, A.I.C. rating. Room numbers of the loads shall be included.
- h. Lightning Protection: Provide a detailed lightning protection plan and grounding plan if required. Indicate counterpoise, air terminals, ground connections, conductor sizes, etc.
- i. Include Arc Flash Hazard rating labels.

8.3.3.3 Checking

Thoroughly check the drawings for discrepancies, for compatibility between drawings and specifications, and for compatibility between disciplines. Drawings shall be computed and checked by separate individuals. Indicate the names or initials of these individuals on the drawings. Provide the appropriate Design Quality Control Checklists as are contained in Appendix A. Checklists shall be edited for the project. Electrical Design Checklists shall be initialed by an Electrical Engineer.

8.3.3.4 Final Specifications

All bracketed choices shall be selected, and blank areas completed. Delete inapplicable publications and text/paragraphs. Add publication references, paragraphs, phrases, words, and sentences for items not adequately covered by specifications.

Do not specify proprietary items unless prior approval has been obtained. However, specifying products by naming acceptable commercial products followed by the words "or equal" is permitted under the following conditions:

- a. There is no Government or commercial standard or specifications for the item.
- b. The item is a minor part of the construction project, and
- c. The item cannot be adequately described because of the technically involved construction or composition.

8.3.4 CORRECTED FINAL (100%) DESIGN SUBMITTAL

The 100% submittal is not considered a formal design level and is provided in those cases in which the approved comments require revision due to error or omission. Incorporate the approved comments generated during the final review into the Final Design Analysis (not amended sheets), specifications, and drawings before they are submitted as 100% Design Documents.

8.4 TECHNICAL REQUIREMENTS.

8.4.1 APPLICABLE PUBLICATIONS.

The most current editions of the criteria, codes, and standards listed below constitute an addendum to this chapter wherever referenced or applicable.

- a. Air Force Manuals and Regulations.
- b. Engineer Technical Letters (ETL) and Engineering Regulations (ER).
- c. Military Handbooks, Manuals, and Standards.
- d. Unified Facilities Criteria (UFC).
- e. Engineering Construction Bulletins (ECB).
- f. Technical Criteria for the Installation Information Infrastructure Architecture (I3A).
- g. American National Standard Institute (ANSI).
- h. National Fire Protection Association (NFPA).
- i. Unified Facilities Guide Specifications (UFGS).
- j. AMC-R 385, Safety Manual
- k. National Electrical Safety Code (IEEE C2)
- l. Installation/Local Guidance and Criteria

8.4.2 BASIS OF DESIGN

Avoid designing based on a single manufacturer's product. Multiple manufacturers must be able to compete to provide specified equipment. During design, verify that at least three manufacturers provide equipment meeting specified requirements. Develop a justification and obtain approval through the PE/A for any equipment or system that must come from a single source.

8.4.3 SYSTEM SELECTION

Concept Energy Modeling and Life Cycle Cost Analyses shall be performed and provided to evaluate the HVAC and lighting systems alternatives a part of the basis for HVAC system selection. The electrical designer shall work closely with the mechanical designer and perform the Life Cost Analyses for the lighting system to determine the most cost-efficient system.

8.4.4 LIGHTING SYSTEM

Design of the lighting system shall be in accordance with UFC 3-530-01, Design: Interior, Exterior Lighting and Controls. Emphasis shall be placed on quality design, and not only horizontal illuminance values; taking into consideration direct glare, surface luminance, and uniformity. An energy efficient lighting system meeting Epect 2005 and ASHRAE 90.1 shall be provided.

8.4.5 SURGE PROTECTIVE DEVICE

Provide surge protection at the power service entrances per NFPA 780. The circuit breaker for the SPD should be in the main panel or main switchboard as close as possible to the incoming feed for most effectiveness. For example, a 3-phase service with the incoming feed at the top of the panel bus, it shall be in the 1, 3, 5 or the 2, 4, 6 pole position. For a main switchboard configuration, it is typically located in the first cubicle. The SPD shall be located as close to the panel/switchboard as possible to minimize lead lengths to the circuit breaker and to the ground bus. SPDs shall not be installed in the panel or switchboard enclosure.

8.4.6 LIGHTNING PROTECTION SYSTEM

Lightning Protection System shall be provided in accordance with NFPA 780 and UFC 3-575-01, Lightning and Static Electricity Protection Systems. LPS roof penetrations shall be limited and are prohibited on standing seam metal roofing systems. Ensure the LPS system does not compromise the warranty of the roofing system.

8.4.7 FIRE ALARM AND MASS NOTIFICATION SYSTEMS

Plans may include notification and detection areas of protection to indicate required coverage in lieu of placement of individual devices.

Mass notification strobes and LED type text signs shall be provided in accordance with ECB No. 2018-17, New Requirements for Visual Notification for Mass Notification Systems. Intelligibility requirements for all areas shall meet UFC 4-021-01, Mass Notification Systems.

8.4.8 COMMUNICATIONS

UFC 3-580-01, Telecommunications Interior Infrastructure Planning and Design applies to all interior telecommunications infrastructure planning, design and installation in new and existing facilities. Inter-Building and Outside Plant requirements for Army installations shall comply with I3A, Army Installation Information Infrastructure Architecture and the Air Force shall be coordinated with the Base Communications Officer until UFC 3-580-02 is published.

8.4.9 PRIMARY ELECTRICAL SYSTEM

UFC 3-550-01 requires the use of aluminum conductors. Paragraph 3-11.1.2 lists conditions copper may be authorized. For the Army, the DPW Chief Engineer, and the Air Force, Base Civil Engineer has the authority to approve the use of copper, but it must be documented in the planning process and the design

analysis. If copper conductors are specified, ensure documentation is provided in the Design Analysis.

8.4.10 CYBERSECURITY

Include cybersecurity requirements per UFC 4-010-06 Cybersecurity of Facility-Related Control Systems. Coordinate with the customer to identify the System Owner and Authorizing Official as early as possible. One Specification 25 01 11 per facility related control system (FRCS) is required. Add a fourth level designator on the specification to distinguish between the different systems. For example, 25 01 11.01 could be designated for Fire Alarm and Mass Notification, 25 01 11.02 for Energy Management Control System.

8.4.11 PROTECTIVE DEVICE TIME CURRENT COORDINATION STUDY

It is insufficient for the DOR to state the coordination study will be performed by the contractor. Per UFC-3-501-01, the coordination study at the design stage is to establish the basis for the system design and to enable completion of an initial arc flash analysis. Ensure Arc Flash Hazard Analysis and Coordination Study is included in the Final Submittal.

----END OF SECTION----