Electrical Design Standard

Electrical work includes, but is not limited to, the design of the following systems: Primary Electrical Distribution Systems, Secondary Electrical Distribution Systems, Lighting Systems, Lightning Protection Systems and Grounding Systems. Electrical designs shall comply with the following:

AFI 32-1062	*Electrical Power Plants and Generators*
AFI 32-1063	*Electric Power Systems*
AFI 32-1064	*Electrical Safe Practices*
AFI 32-1065	*Grounding Systems*
ETL 11-9	*Electrical Manhole Entry Work Procedures*
ETL 99-4	*Fire Protection Engineering Criteria Emergency Lighting and Marking of Exits*
ETL 11-21	*Emergency and Standby Generator Design, Maintenance, and Testing Criteria*
NFPA 70	*National Electrical Code, 2011* (latest editions and all that
apply) NEMA	*National Electrical Manufacturers Association*
ANSI C2	*National Electrical Safety Code, 2012*
10 CFR 435	*Energy Efficiency Standards for New Federal Low-Rise Residential Buildings*
Army TM 5-811-6	*Electric Power Plant Supply*
Army TM 5-811-1	*Electrical Power Supply and Distribution*
AFPAM 32-1192	*Energy Efficient Motors and Adjustable Speed Drives*
UFC Series 3-500	*Electrical*
UFC Series 3-600	*Fire Protection*

IES Lighting Handbook, 10th Edition

IEEE, ANSI, and UL Standards, latest editions and all that apply

Please note that compliance with current ETLs, AFIs and Industry Standards not listed above is mandatory.

1.1 Drawings, Specifications and Design Requirements

Electrical drawings shall provide all necessary construction details for proper installation and accurate bidding. Electrical drawings shall include, but not be limited to the following:

- One Line Diagrams showing all switchgear, switchboards, panel boards, enclosed switches, enclosed breakers, transformers, generators, UPS systems, switches, meters, surge arresters, motors, motor controllers, reactors, capacitors, contactors, feeder conduit sizes, feeder conductor sizes, breaker ratings, fuse ratings, and available interrupting current (AIC) ratings (Riser Diagrams may also be included, but are not a substitute)
- Control Diagrams for all motors
- Panel Board Schedules for all new and revised panel boards
- Lighting Schedules listing the salient features of each new luminaire
- New and removed items clearly located and delineated
- Installation and removals shall be shown on separate plan views and/or section views
- Legend with all symbols used in the design
- List of all abbreviations used
- Wiring Details showing phase, neutral and home run conductors for each circuit
- Hazardous Areas (i.e., Class, Division, and Group per NFPA 70) shall be clearly identified and labeled on the drawings
- Power rating of all motors shall be shown
- Special grounding and isolated grounding details

Electrical specifications shall be based upon the UFGS and shall detail requirements for all electrical materials that will be used during the construction of the designed project. Design requirements shall include the following:

- The electrical engineer responsible for the design shall visit the site and verify existing conditions.
- The electrical designer shall perform load analysis which shall determine the size of the new load and if the existing electrical distribution system is capable of supporting the new load. If the existing electrical distribution system is not capable of sup- porting the new load, electrical designer shall design required changes to properly support the new electrical load.
- The electrical designer shall perform short circuit analysis to determine the short circuit rating required for all overcurrent protective devices.
- The electrical designer shall perform a coordination study to ensure that the new distribution system is coordinated and will coordinate with the existing distribution sys- tem.
- The electrical designer shall perform life cycle cost analysis on major

components, and any components requested by the government, to achieve the lowest total system cost.

- The electrical designer shall perform voltage drop calculations on all services, feeders, and on the worst case branch circuits for each panel board and switchboard.
- The electrical designer shall perform lighting calculations for each room and site. Calculations shall be based upon maintained foot-candle intensity and Illumination Engineering Society of North America (IESNA) recommendations.

1.2 Medium Voltage System Requirements

The prime contractor shall coordinate with 354 CES/CEOFE Electrical Systems for all additions, connections and alterations to any medium voltage source. Overhead construction is preferred. If overhead construction is used, the poles and hardware must match the feeder on which it is attached. All laterals must have a disconnecting means (fuse cut outs). Connections to pole top transformers must use a stirrup and hot clamp connection. New pad mount transformers installed on Eielson AFB proper will be dual wound 7200/12470. Voltages North of Bear Lake substation are 7200-12470 Delta-Wye. Voltages past Quarry Hill substation are 14400-24900. New connections to existing under-ground medium voltage system shall be made via a spare way on a four-way 15kV 600 amp(A) sectionalizing switch. If a spare way is not available, design shall include a new pad mounted four-way 15kV 600A sectionalizing switch that is interconnected to an existing loop circuit.
Aerial construction.
Aerial lines will be installed in all areas, except in the following instances:
(1) Where aerial lines would constitute hazards such as near flight lines (where poles must be outside of the glide slope path) or near munitions buildings.
(2) Where aerial lines would obstruct operations (e.g., interfere with crane-type, materials-handling equipment)
(3) Where aerial lines would interfere with high-frequency communications or electronic equipment.
(4) Where aerial installations would conflict with current policy for Family Housing Areas.
(5) Where areas have such high load densities that underground electric lines are economical.
(6) Where aerial lines would be incompatible with the environment or architectural concept.
Aerial conductors.
(1) Sizes. Where possible, conductor sizes will be limited to a maximum of No. 4/0 AWG copper or equivalent aluminum. The economical minimum conductor size for circuits serving administrative, support, and housing areas is No. 2 AWG.
(2) Material. Aluminum conductor steel reinforced (ACSR), aluminum alloys, or hard drawn copper (CU) may be used for medium voltages. Low voltage conductors may be of aluminum alloys with ACSR messengers or of copper.

(3) Poles. Solid wood poles will be used for electrical distribution lines, while concrete and steel poles will be used for roadway or area lighting circuits carried underground or separately from distribution lines. Pole lengths will be selected conservatively, making allowance for the installation of communication lines and the required pole setting depth.
(4) Location. Where possible, electrical distribution shall be located along street or roads to avoid the use of separate poles for street lights.
(5) Configuration. Crossarm mounting will be used for main base overhead electrical distribution systems, Transmitter road (until it transitions to single phase) and JPRC. Armless mounting will be used for corners and in high wind/ice areas.
(6) Reclosers and sectionalizers. Reclosers and sectionalizers shall be fully rated and coordinated. Electronically controlled reclosers are preferred over hydraulically controlled ones. Reclosers may utilize vacuum or oil as the interrupting medium. Sectionalizers shall be automatic loadbreak, manual recock, and installed only as an integral part of the system protection scheme. They should not be installed for switching purposes only.

Underground construction.
Underground lines will be coordinated with the installation master plan to avoid conflict with construction of future facilities.
(1) All primary and secondary underground cables will be installed in either concrete encased ducts or direct bury type ducts or conduit. No direct burying of cable will be allowed.
(2) Nonmetallic-jacketed cable will be used, except where circumstances warrant other coverings. Ethylene-polyethylene-rubber (EPR) will be used for all installations.
(3) Low-voltage cables that will be installed outside or transition outside will be Moisture-and-Heat-Resistant Cross-linked Synthetic Polymer (XHHW).

Manhole and Handhole Requirements. New manholes shall include pulling irons opposite all ducts and cable rack supports on all four manhole walls. All new cables in manholes shall be routed the long way around the manhole to provide slack for future splices. Provide racks as required to properly rack all new cables in manholes. Electrical work in manholes shall con- form to ETL 11-9 Electrical Manhole Entry Work Procedures. Hand holes and manholes shall be rated to withstand the load based on the application.

Pad-Mount and Building Service Transformers. Pad-mount transformers shall be dead front, with Off/On switch on the primary side, fluid level indicator and temperature gauge, oil sample and fill valve and shall be located a minimum of 10 feet away from any facility. Transformers shall be copper wound unless approved by the 354 CES/CEOFE Electrical Systems. New transformers shall be sized with a minimum of 25 percent spare capacity for future load. Ensure transformers shall not contain polychlorinated biphenyls (PCBs). A label indicating "No PCB containing fluids" shall be attached to the transformers. Building Service Transformers shall be copper wound, pad mounted outdoor type, mineral or synthetic oil filled, rated at 480Y/277V, 208Y/120V or 120/240V single phase.

Medium Voltage Switches, Relays and Control Conductors. Medium voltage switches shall be pad-mounted outdoor type, vacuum interrupter type and dead front construction. O vercurrent relays shall match existing relays base wide. Relays shall have 5A phase inputs, 5A ground inputs, Type S1 case, 48/125V direct current (DC) power supply and

ASCII RS-485 communication protocol. Control Conductors shall terminate in un-insulated ring terminals. Control conductors shall be color coded IAW National Electrical Manufacturers Association (NEMA) WC 30, Method 1. Terminal blocks for control conductors shall have double rows of screw terminals be rated for up to #10 American Wire Gauge (AWG) conductors, be rated 30A minimum, have tin plated terminals and blocks be made of a phenolic compound. Terminal blocks for current transformers shall have shorting blocks and screws.

Equipment Pads and Switch Ducts. New concrete equipment pads for external pad mounted transformers, switches and other electrical equipment shall have thickened edges. Interior floor mounted transformers, switches and other electrical equipment shall be raised at least 4 inches on a concrete pad for housekeeping purposes. Switch ducts from new 15kV switches shall go to a manhole before going to a transformer or another 15kV switch.

Metering. Electrical meters shall be provided for all facilities. They shall have remote reading and pulse output capability, and be compatible with the Eielson AFB radio frequency system. By-customer subdivision of meters within a facility is required.

1.3 Low Voltage Systems

New low voltage conductors shall be copper and those installed below grade shall be type XHHW. Maximum conductor size shall be 500 kcmil. Conductors shall be paralleled as required to comply with this requirement.

Neutral Bus Rating. 208Y/120V or 120/240V Branch Circuit Panel boards shall have 200 percent rated neutral bus.

Nonlinear Load Supply Requirements. Panel boards that supply power to nonlinear loads (electronic equipment affected by electrical noise i.e., computers, printers, fax machines, copiers, etc.) shall also have an isolated ground bus. Do not use shared neutrals for any circuits. Neutrals that are part of a panel board feeder that feeds nonlinear loads shall be oversized to a minimum of one trade size larger than the phase conductors.

Bus Requirements. Panel boards, switchboards and switchgear shall have copper bus. New panel boards and switchboards shall have a minimum of 20 percent spare space for future addition. New panel boards and switchboards shall be balanced to the maximum extent possible.
Switchboards and switchgear shall have raised 4 inch concrete pad for housekeeping purposes.

Panel Board Requirement. Panel boards not in sight of the feeder over current protection shall have a main circuit breaker. Panel boards shall have hinged front covers. Panel boards shall have bolt on style circuit breakers. Panel boards shall be recessed mounted as much as possible.

Electrical Rooms. The headroom above electrical equipment in electrical rooms shall be free from plumbing piping (gas, water) and HVAC equipment. Avoid routing gas, water, piping

and HVAC duct work through electrical room. Electrical room space shall be climate controlled.

Transformers. All new transformers shall be sized with a minimum of 25 percent spare capacity for future load. New transformers shall have copper windings and new transformers that supply computer loads shall have an electrostatic shield. Single phase transformers may not be banked into three phase transformer banks.

Raceways. Conceal interior raceways. An electrical metallic tubing (EMT) raceway shall be connected to enclosures and other raceways with compression type connectors. Set screw type connectors shall not be used for EMT raceways.

Feeder Sizing. Feeders shall be sized for a maximum 2 percent voltage drop. Branch circuits shall be sized for a maximum 3 percent voltage drop.

Conduit Grounding Requirement. Each conduit shall include a copper equipment grounding conductor sized IAW NFPA 70. Equipment grounding conductors shall be insulated.

Duct Bury Depth. Ducts installed below grade shall be 2 feet minimum. All ducts installed below grade shall be Rigid metallic tubing or concrete encased. No direct buried wiring will be accepted. All ducts shall be installed on bedding material and concrete encased regardless of location. Additionally, high voltage ducts shall have a red warning indicator installed 12 inches above the duct.

Device Wiring Requirement. Receptacles and other wiring devices shall be wired with the screw terminal connections, not the push in connections.

Outdoor wiring. Outdoor wiring shall be arctic rated to -50°F.

Head Bolt Outlet Requirement(HBO). HBOs will be installed so that 1 circuit shall feed 2 duplex outlets. HBO risers will be concrete encased metallic tubing to protect from vehicular traffic.

1.4 Motors

Motors must meet or exceed Energy Standard 10 CFR 435 to achieve maximum energy conservation. Motors less than 1/2 horsepower (HP) shall be single phase. Motors larger than 1/2 HP shall be poly phase. Provide power factor correction for all motors 7.5 kilo Watt (kW) (10 HP) and larger. Power factor correction shall be to 95 percent at rated load for the motor. Soft start or reduced voltage starting is required for all motors 15 kW (20 HP) or larger.

New motor controllers shall include hand-off-auto switch. New pilot lights shall be a LED type with a replaceable lamp unit. Motor controllers shall be of magnetic, across-the-line type, reduced voltage and current limiting type. Motor control centers shall have disconnect

switches, branch circuit overload protection and be controller mounted in a single assembly. Motor control circuits shall not exceed 120 volts to ground. For ground neutral systems, the neutral conductors shall be directly connected to the started coils.

In HVAC and Plumbing designs, variable frequency drives (VFD) shall be used in applications where partial loading occurs. VFDs shall be of 12 pulse design and include a 3 percent line reactor; or VFD's shall include a low pass harmonic filter designed to reduce the total harmonic current distortion to 12 percent or less. Low pass filters shall have the capacitors switched out when the motor is not operating. VFD rated motor cable shall be used for the circuits from the VFD to the motor.

1.5 Service Equipment

Service entrance equipment shall be located in readily accessible spaces to permit the quick disconnect of power in case of emergency. The service entrance location shall be coordinated with the exterior electric system through 354 CES/CEOFE to ensure that electrical service and feeder circuit lengths are as short as practicable. Low voltage service conductors (600 volts or less) shall be installed underground from transformers to service entrance equipment. Services exceeding 600 volts will be limited to large facilities requiring several load centers. The high volt- age service conductors shall be installed underground from the transformer to the service en- trance equipment. Service equipment capacities shall be adequate for the estimated load plus 10 to 20 percent for future growth. Generally there shall only be one service disconnect for each facility. At each service entrance provide one kWH demand electric meter with remote capability communication which can be connected to the Eielson AFB EMCS/SCADA system.

2 Grounding

Grounding electrodes shall be copper metallic rods not less than 3/4 inches in diameter, 8 feet long and driven into the ground outside the facility. Ground rods may be installed in multiples on a lateral spacing not less than their buried depth. Electrode resistance to ground shall not exceed 25 ohms under normally dry conditions. Communication facilities electrode resistance to ground shall not exceed 5 ohms under normally dry conditions. All grounding type outlets and receptacles shall be grounded by a separate ground conductor. Grounding shall comply with NFPA 70 requirements.

2.2 Wiring systems and Circuits

Wiring systems shall consist of insulated copper conductors installed in metal raceways, Branch circuits shall be rated a minimum of 20 amperes. In designing circuits, the

combined voltage drop on feeders and branch circuits shall not exceed 5 percent. Raceway and conduit size shall be IAW the provisions of the National Electric Code. All wiring in transformer rooms shall be in rigid steel conduit wiring troughs or busways. Use of plastic conduit within structures shall be limited to applications below concrete slab-on-grade construction or in highly corrosive non-hazardous locations. Aluminum conduit shall not be buried in concrete. Flexible metal conduit shall be used for permanent connection to large apparatuses and motors where movement may be involved. Flexible metal conduit may also be used for lighting fixture connections above suspended ceilings. All new interior wiring shall be enclosed by the raceway within walls, floors or ceilings. Exposed wiring or carriers are not allowed. Non-metallic sheathed cable (Romex) is not allowed. Surface mounting may be considered for extreme situations in remodeling projects. Under floor raceway may be used in large administrative areas where an extensive power and communication requirement cannot be adequately served by wall outlets. Busways may be used for feeders and service entrances when they are more economical than equivalent-capacity insulated conductors in raceways. Plug-in busways may be used in industrial or shop areas to serve a multiplicity of power outlets or motors. Cable trays may be used as a support system for multi-conductor type cable such as underground feeder or service entrance, as permitted by NFPA 70. A dedicated circuit shall be provided for all computers and sensitive electronic equipment. System furniture to be installed shall have all work stations prewired.

2.3 Lighting

Providing safe and useable areas for Eielson AFB functions during non-daylight hours requires position well-planned lighting systems at appropriate locations. Well-planned lighting systems which conform to the Eielson AFB lighting system standards shall be provided. Energy efficient fixtures, lamps and systems in general shall be used. Do not exceed 80 percent of the lighting power densities for exterior areas and 50 percent for building facades and landscape features as defined in ANSI/ASHRAE/IES Standard 90.1-2010, *Exterior Lighting Section*, with- out amendments. To reduce light trespass, adopt site lighting criteria to maintain safe light levels while avoiding off-site lighting and night sky pollution. Use cut-off luminaries and low- angle spotlights. Use 100 percent cut-off lighting on building exteriors. Use of common non- cutoff "wall-pack" units for exterior building lighting is prohibited.

Illumination Levels. General exterior illumination levels and cut-off fixture requirements shall be provided as determined necessary for the activity zones determined IAW IESNA RP-33 un- less an applicable UFC, AF or DoD standard is otherwise specified.

Support Types. Street light fixture poles shall be rated for 100 mph sustained winds. Parking lot light shall be square aluminum housing and dark duranodic bronze finish, rated for 90 mph sustained winds. Lighting fixtures for parking lots shall be shoe box style with aluminum housing and dark duranodic bronze finish. When used, the luminaire must be shielded to prevent glare and allow preservation of night vision. Sports lighting shall be adequate for the function and orientated to prevent glare and light trespass into the surrounding areas. Accent lighting shall be used when it is desirable to highlight architecture,

landscaping or site furnishings.

Exit and Emergency Lighting. Exit signs and emergency lighting shall be provided as required by the NFPA 101. Exit signs shall be light emitting diode type with green letters. Emergency lighting shall be provided by integral battery operated, fixed lighting units. Exit and Emergency Lighting shall conform to ETL 99-4.

2.4 Lightning Protection

Lightning protection air terminals and conductors shall be copper unless installed on an aluminum or steel surface.

2.5 LED Lights

LED lighting must conform to the following ETL's:

2.5.1 ETL 11-29 *Use of LED Fixtures in an Airfield Lighting System*

2.5.2 ETL 12-15 *LED Fixture Design and Installation Criteria for Interior and Exterior Applications*