ELECTRICAL

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I. ELECTRICAL

A. GENERAL

1. *Description*

This division provides information on basic materials and methods for providing and installing electrical service, distribution, lighting, special systems, communications and controls for new construction and rehabilitation projects at The University of North Carolina, Chapel Hill.

"Interested parties", as used in the following guidelines, includes: UNC Project Manager, Building Representative and UNC Facilities Services.

2. *Applicable Codes, Regulations, and Standards*

- The following codes (latest edition) shall apply:
  - National Electrical Code (NEC)
  - The NC State Building Code
  - Occupational Safety and Health Act of North Carolina (OSHANC)
  - Code of Federal Regulations (CFR) 1910.269
- The following standards (latest edition) apply:
  - North Carolina State Construction Office Electrical Guidelines:
  - https://ncdoa.s3.amazonaws.com/s3fs-public/documents/files/2011_Electrical_Guidelines.pdf
  - https://ncdoa.s3.amazonaws.com/s3fs-public/documents/files/State-of-NC-SSL-Guidance-Document.pdf
  - Underwriters Laboratory (UL)
  - Illuminating Engineering Society of North America (IESNA)
  - National Fire Protection Association (NFPA)
  - National Electrical Manufacturers Association (NEMA)
  - American National Standards Institute (ANSI)
  - Requirements for Fire Detection and Alarm Systems/Smoke Detectors Meeting State Requirements, Department of Insurance, State of North Carolina, Latest Edition.
  - Institute of Electrical and Electronic Engineers (IEEE)

Local utility regulations governing connections and metering require an electrical inspection certificate from the State Electrical Inspector, State Construction Office prior to approval for final payment and before energizing any new transformers and electrical service. UNC Engineering Services shall be notified prior to energizing electrical distribution to allow inspection. Adjustable breakers shall be set per designer's short circuit coordination study and testing completed as specified.

Where the above Applicable Codes, Regulations and Standards conflict with these guidelines; the more stringent of the two criteria shall prevail.

3. *Equipment Identification*

Prior to energizing, all equipment shall be properly identified with equipment identification, equipment controlled, panel and circuit feeding equipment, electrical ratings, and date of installation. All electrical distribution equipment, including motor disconnects and VFDs shall have arc flash labeling containing incident energy and arc flash and shock boundaries provided by electrical designer to contractor.

4. Electrical Systems Training and Maintenance Manuals

No training will occur until UNC Engineering Services has approved installation is ready for training. The instruction time periods shall be approved by the Owner and conducted during normal working hours, Monday through Friday, at the job site. Owner's facilities staff will be trained in proper maintenance and how to operate and make adjustments on all equipment. Training on specialized equipment shall be by manufacturer's authorized representative. Maintenance manuals and copies of programmed inputs to software shall be provided prior to training. Maintenance manuals shall include project's manufacturer's shop drawings and program inputs for control systems, such as lighting dimming systems and emergency load shed programs. The Owner reserves the right to request replacement of any instructor who, in their opinion, does not demonstrate sufficient qualifications as an instructor. Final acceptance of the project will not be given until all specified training is completed.

Contractor shall provide the owner two copies of all red-lined drawings at beneficial occupancy or owner maintenance acceptance of project, whichever is first. One copy shall be placed in main electrical room and one copy in UNC Facilities Services plan room.

5. Acceptance Criteria

Prior to specified training, the Contractor shall conduct the specified operation acceptance test, with 7 days' notice for witnessing by UNC Building and Engineering Services and the designer of record. Submittal copies of reports documenting all specified tests shall be specified and approved by designer. and included in the maintenance manuals.

B. WIRE AND CABLE

- Interior branch circuits serving 120/208, multi-outlet receptacles shall not require greater than No. 10 wire to comply with maximum 3% branch circuit voltage drop, Panels shall be located to accommodate this requirement for maximum voltage drop and maximum wire size. Fully loaded multi-outlet receptacle circuits shall be assumed in sizing wiring for voltage drop on these circuits.
- For open office spaces, where systems furniture is not included in the contract, provide notation on drawings for contractor to coordinate exact locations and number of circuits with individual neutrals required at each location for furniture feeds for receptacles and telecommunication outlets with owner and furniture vendor.
- Furniture and pre-fabricated walls' circuit wiring shall fully comply with these guidelines and SCO Electrical Guidelines. For example, wiring shall be specified with individual neutrals and green equipment grounding conduct in EMT conduit. Exception for furniture baseboard wiring, which is readily accessible, wiring with individual neutrals and green grounding conductor may be in flexible conduit. Proprietary wiring or conduit connectors are not to be allowed in or for connection to prefabricated walls or furniture. Connectors shall be conventional type for EMT or flexible conduit.
- All conductors, without exception, shall be copper. Aluminum is strictly prohibited.
- Size all neutral wires for 3 phase systems equal to or larger wire size than the phase conductors. All single-phase circuits shall be provided with individual neutral. Utilizing multi-pole breakers for single-phase circuits sharing a neutral is not allowed.
- No more than three current carrying conductors allowed per conduit, except three single-phase branch circuit conductors, each with individual neutrals, shall be allowed in a conduit.
- MC, AC or "BX" cable is not allowed.
- Do not mix conductors of different voltages in the same raceway, pull box or junction box. Do not mix generator back-up circuits (NEC 700, 701 or 702) with normal circuits in same raceway or junction boxes. Exception: Where control wiring is a different voltage from power for the same system.

C. CONDUITS

Minimum conduit size is 3/4" (interior) and 1" (exterior) for premises wiring system. Exception: 1/2" flexible metal conduit not exceeding six feet may be used for fixture and small equipment drops.

Conduits shall not be run in building slab, unless agreed to by all interested parties and approved by UNC Engineering Services. Specify in bid documents that conduit is not to be run in building slab except where specifically indicated in drawings.

Conduit shall be routed in ceilings with a minimum of 18 inch spacing from terminal boxes' maintenance access locations.

D. OUTLET, JUNCTION AND PULL BOXES

All outlet and switch boxes used for interior wiring shall be metallic and a minimum volume of 18 cubic inches. Exception: Special application such as moisture proof or hazardous location.

Provide sufficient duplex convenience outlets in mechanical and electrical rooms to enable maintenance to service equipment with plug-in lights and tools in accordance with 2014 NEC.

Provide duplex convenience outlets in all spaces, including corridors for housekeeping floor cleaners. Install corridor outlets on separate circuits from assigned adjacent spaces.

Freezer farms shall be provided with both 120V and 208V dedicated receptacles with generator backup at each location where a freezer could be located.

Do not install receptacle outlet boxes back to back. A minimum 6 inch spacing of receptacle outlet boxes serving opposite sides of a wall shall be maintained.

Junction and pull boxes above a suspended ceiling shall be located between three (3) and thirty-six (36) inches above the suspended ceiling for accessibility. Removal of duct or ceiling grid shall not be required to access pull or junction boxes. Note, pendant fixture boxes are not allowed more than six inches above ceiling grid. Specify contractor coordination shop drawings for congested corridor above ceiling spaces.

Junction boxes shall be labeled with circuits contained using panel and circuit identification.

E. WIRING DEVICES

All receptacles and fixed equipment shall have a permanent label indicating panel and circuit number.

Do not use device as junction or feed-through. Pigtail the branch circuit wires to attach device.

Individual ground fault receptacles are required in lieu of ground fault breakers. Use of feed-through ground fault receptacles shall be determined by end-user. For stand-by GFCI receptacles, as in animal quarters, feed-through type is not allowed.

F. GENERATOR SYSTEMS AND TRANSFER SWITCHES

1. General

Modeling of generator exhaust emissions and personal exposure is required. Contact UNC-EHS for data sheet to be completed for project generator as early as possible in design phase, no later than Design Development Phase. UNC-EHS will provide this detailed information to an Environmental Engineering consulting firm in order to mathematically model both environmental emissions and personal exposures, including adjacent buildings and pedestrian pathways. **Refer to UNC Emergency Generator Policy for requirements on permitting, locating and sizing generators at UNC-CH.**

This modeling will be based on anticipated EPA Tier Level. EPA Tier Level shall at least meet the minimum Tier requirements in the year the generator is expected to be purchased, based on project bid schedule. A higher Tier level may be required based on modeling results. Space for future retrofits to reduce emissions shall be provided at generator location.

Generator should be sized for 50-75 percent of expected building load upon completion. Generator sizing should also take into consideration possible addition of adjacent building loads where existing generators need replacement. To prevent over-sizing for starting load and harmonics, specify stepped loading, variable frequency drives or reduced starting controls, and loads with lowest harmonics available or harmonic mitigation on high harmonic loads. Generator compatibility with elevators and large computer center's UPS loads on generator shall be confirmed during design and final system testing.

A generator matrix identifying all generator loads by equipment ID and a load table with both running and starting demand shall be provided in DD drawings and updated in CD and bid document drawings.

Stepped loading and priority of load shedding shall be indicated on drawings. Identification of Emergency Life Safety distribution electrical equipment shall be labeled "Life Safety Loads Only" or equivalent. A separate feeder from generator and a dedicated transfer switch is required for each BL3 lab and animal quarters lab. Where load shedding is anticipated and multiple transfer switches are utilized, the designer should confirm appropriate transfer switch(es) for critical building loads, including redundant loads, with building occupants and facilities. Design intent for transfer switch loading shall be captured in narratives, during maintenance training and commissioning final reports.

The University maintains and services all emergency and standby generators on campus. The Contractor shall provide any site specific and end user type training of the system. Additionally, where any specific computers, printers, cabling, software and/or license agreements are necessary for the University to have the capability to develop a database and/or modify any operating parameters for the buildings emergency and/or standby generator system without permission from outside distributors. A schedule of available manufacture certification training shall be provided. This training and certification shall recognize the University as a trained and licensed Generator System installers independent of local distributors and shall not be included in the price of the base bid. The authorized representative will coordinate and necessary proprietary agreements, training arrangements, costs, and specific support equipment needs with the owner.

Designer is responsible for incorporating all UNC and SCO applicable criteria in the bid documents and providing a complete performance specification.

2. Manufacturer's Qualifications

Firms regularly engaged in manufacture of generator systems of types, sizes, and electrical characteristics required, and whose products are Listed and Labeled by UL, Inc. All replacement repair parts shall be as

produced or supplied by the same manufacturer as the generator system or transfer switch as applicable. Products of firms that do not maintain factory authorized service organization and spare parts stock within 2 days standard shipping are not acceptable for use on this project.

Manufacturers shall agree to make factory training/certification, product programs/software and/or operating systems, and continued product updates and/or Tech notes available to the University. Required software updates shall be made available at no cost. Software shall be capable of connecting to University network with remote control by University. Any licensing and/or proprietary agreements between the manufacturer/distributor and the University must be completed and in place prior to the manufacture and/or product being acceptable for installation.

Acceptable transfer switch manufacturers who have agreed to provide factory training/certification to UNC are ASCO, Onan, and Russell. Two preferred alternates shall be bid. These preferred alternates shall be 1) ASCO without http connectivity without bypass isolation and 2) ASCO with http connectivity, as described below (may also be bid without bypass isolation). Short circuit rating of ATS shall be indicated on plans.

Acceptable generator manufacturers who have agreed to the provide factory training/certification to UNC are CAT, Cummins and Kohler.

3. Submittals

A copy of all submittals will be provided for UNC Life Safety Review.

Submittals shall demonstrate compliance with technical requirements by reference to each subsection of the specification. Where a submitted item does not comply fully with each and every requirement of the specifications, the submittal shall clearly indicate such deviations and may be subject to rejection. Identification requirements for non-complying features of items are very specific.

The submittal shall include, at a minimum, the manufacturer; model and catalog numbers, dimensions, construction materials, operating and performance characteristics, controls, finish any other pertinent information, and typical shop drawings.

- Installer Certifications: Copies of manufacturer signed certifications as required.
- Product Data: Submit (3) copies of any Manufacturer's technical product data, including specifications, installation instructions, and owner's manuals.
- Maintenance Data: Submit (3) copies of any maintenance data and parts lists/manuals for the specific type of generator system installed, including any furnished specialties and accessories. Include recommended operator manuals, service manuals, recommended preventative maintenance, pertinent project specific wiring diagrams and controls manuals, any manuals of sequential operations, and any controller and diagnostic manuals and software as required in section 1.
- Owner Training and Certification: Provide the owner a current factory approved certification/ training schedule for the specific system installed.

4. Packaged Engine Generator Requirements

- Provide a 4-pole alternator, with drip-proof construction, revolving field type, protected and sized for maximum motor starting loads. Insulation shall be Class F per NEMA MG1-1.65. Rotor is dynamically balanced and permanently aligned to engine by flexible disc coupling.
- Voltage regulation shall be solid state temperature compensated with phase controlled sensing.
- Provide heavy duty ball bearings, permanently lubricated.

- The generator engine shall have sub-transient reactance of 12 % maximum.
- Two-thirds pitch stator winding and fully linked amortisseur winding shall be provided.
- Electronic fuel ignition control shall be provided.
- The governor shall be electronic, adjustable isochronous, with speed sensing.
- Provide permanent magnet excitation.

5. *Noise*

Control noise exposures in adjacent buildings below 60dB averaging for speech frequencies of 500, 1000, 2000 and 4000.

Noise levels 1 meter away from generator and 1 meter from ground shall be 82dBA or less.

City Ordinances must be met when generator is located close to property boundary.

6. *Fuel oil tanks*

Any fuel transfer pump shall be approved by the UNC Life Safety Emergency Generator Shop.

Minimum capacity of sub-base fuel tank shall be 100 gallons or guaranteed volume to operate the system 68 hours at demand load, whichever is greater.

Install diesel fuel tanks above ground and in accordance with the UNC Spill Prevention Control and Countermeasures (SPCC) Plan Design Guidelines.

The Contractor shall fill fuel oil tanks immediately after installation using Ultra Low Sulfur Diesel (ULSD) with a sulfur content not to exceed 15 parts per million, and refilled immediately with ULSD prior to acceptance of the building.

7. *Exhaust*

Locate exhaust above roof level, away from the air intake area of the building and adjacent buildings, trees, combustible materials and pedestrian traffic.

Generator exhaust must discharge vertically for maximum dispersion modeling. Rain cap shall fully open without impeding vertical discharge when generator is running. Provisions for maintenance access to Raincap shall be provided, with using lifts or scaffolding.

8. *Outdoor Enclosure*

Adequate emergency lighting with battery backup shall also be installed in outdoor enclosures.

If generator breakers or other generator components requiring maintenance access are over 6-1/2 feet above grade, a platform is required such that all maintenance parts of generator are not over 6-1/2 feet above grade. Platform shall be a minimum of 4 feet deep. If platform is more than 2 feet above grade a rail is required.

9. *Interior Locations*

Generator Rooms, in buildings, shall have sealable floor drains to facilitate clean-up with a water supply within 50'. Transfer switches shall be located in dedicated electrical room in new or completely renovated buildings.

Foreign systems piping shall not be located above switch within the working space of switch up to structure (not just 6-1/2 feet above switch).

Louvers with gravity dampers shall be provided. Pneumatic/BAS controlled louvers are not allowed.

10. *Engine-generator controls*

Contain the engine-generator controls in a shock mounted cabinet; use digital controls and metering where practical. Provide the following controls and metering:

- AC Voltmeter (2% accuracy) 3 1/2"
- AC Ammeter (2% accuracy) 3 1/2"
- Phase Selector Switch/Current Transformer each Phase
- Frequency Meter
- Running Time Meter
- Oil Pressure Gauge
- Water Temperature Gauge
- Battery Charging Ammeter
- Voltage Adjusting Rheostat
- Auto-Start-Stop Control
- Safety Shutdown and Alarm Light for:
    - High-water temperature
    - Low oil pressure
    - Engine over-speed
    - Engine over-crank
    - Auto-Off-Reset Switch
- Panel Lighting

11. *Remote annunciation*

Location of remote annunciator and/or data link shall be determined with the building occupant and Project Manager. Though not always necessary in every application, do not install in a Building Generator Room.

12. *Installation*

Location shall include one 120VAC emergency power outlet for maintenance use.

Generator feeders shall be continuous, without splicing from generator breaker lugs to breaker lugs feeding transfer switch.

G. AUTOMATIC TRANSFER SWITCHES

The automatic transfer switch shall be either 4-pole or 3-pole with overlapping neutral, solid state controlled, rated for all classes of loads, both inductive and non-inductive, and mechanically held on normal and emergency. Transfer switch shall have bypass isolation for all critical load unless ASCO bid alternate without bypass isolation is accepted. Full-size neutral contactor shall be provided. Bypass isolation shall be provided in separate enclosure compartment from automatic transfer compartment, where this isolation is available for size of transfer switch specified. The need for closed transition transfer switch shall be determined during design with building representative and UNC Life Safety Shop.

1. Components

In addition to SCO Electrical Guidelines, the following transfer switch controls shall be included:

- Anti-single phasing protection shall detect regenerative voltage as a failed source condition.
- Time delay on transfer from normal to emergency adjustable 0 to 120 seconds.
- Time delay on stop - adjustable 0 to 8 minutes.
- Under frequency - under voltage relay for emergency source.
- Load shed feature shall be provided on transfer switches serving optional loads where connected load and future spare exceeds generator rating. Where provided, control shall provide for loads to automatically add back upon reduction of total generator load. UNC shall be provided software that allows UNC to change load priority.
- Priority of optional load shedding shall be determined during design and indicated on plans.
- Light-emitting diodes shall indicate time stamp logging.
- No mechanical piping systems, i.e. steam or water piping, shall be located above NEC required working space to structure. Switch shall be located clear of any maintenance valve operations on steam or water piping. For new buildings and existing to extent possible, switches are to be located in dedicated electrical room.

2. Remote http connectivity with ASCO transfer switch without bypass isolation (Bid As Preferred Alternate)

Monitoring and control of power transfer switches in the Emergency or Standby Power Distribution System. Local Area Networks and Remote networks are supported with either single or multiple points of access, and web-enabled communications allow access to campus power systems from anywhere around the world.

- Monitors and Controls Power Transfer Switches and Engine Generators.
- Monitors Normal and Emergency Voltages and Frequency.
- Indicates Transfer Switch Position and Source Availability.
- Provides Transfer and Retransfer of Loads for System Testing.
- View Normal and Emergency Voltage and Frequency Settings.
- View Transfer Switch Time-Delay Settings.
- Provides Transfer Switch Rating and Identification.
- Automatic Paging Notifies Personnel, by E-mail or Pager, or Selected System Alarms.
- View Current, Power and Power Factor with ASCO Power Managers Connected to the System.

H. GENERATOR / TRANSFER SWITCH SYSTEM TESTING & CERTIFICATION

1. Database and Engine Inspection

The Contractor/Installer must 100% test all site-specific software functions and/or set parameters for the system and provide a written test report or detailed check list. This documentation must include an engine diagnostics report, a hard copy of the completed program, and wiring diagrams.

a) The complete final configuration database (site-specific programming) for the system must be permanently stored on a computer disk or CD and archived by the manufacturer or authorized distributor. A disk or CD copy of that database must also be provided to the Owner when the system is commissioned.
b) The Manufacturer or authorized distributor must maintain software version (VER) records on the system installed. The system software shall be upgraded free of charge if a new VER is released for any reason during the warranty period. For any new VER to correct problems, free upgrade shall apply during the entire life of the system.

2. Contractor/Installer Field Testing

Upon completion of the installation Contractor and the Manufacturer's authorized representative together shall 100% test and instruct the Owner's designated employees in the proper system operation and in all required periodic maintenance. Performance Testing shall include all permanent building loads with supplemental load bank to generator's rating and in accordance with NFPA 110-2002, including cycle crank and performance tests. Operation of elevators and monitoring of any permanently installed UPS systems shall be provided during test.

a) The owner shall be given advance notification in order to witness testing.

b) Testing shall be performed using all installed generator loads supplemented with additional load to generator's nameplate rating. Where more than one building is on a generator, all buildings' loads will be utilized. The maintenance instruction shall include three (3) copies (minimum) of a written, bound summary of items covered for future reference.

c) The documentation shall be part of the programming reports. The contractor shall keep history of all deficiencies determined. All deficiencies shall be corrected and retested. Once this has been accomplished, the contractor shall submit to the A/E all documentation of all problems and corrections and request the A/E to inspect and test the system.

I. VARIABLE FREQUENCY DRIVES – RELOCATED TO MECHANICAL GUIDELINES

J. ALARM AND DETECTION SYSTEM CENTRAL ALARM RECEIVING SYSTEM

The University has a Central Alarm Receiving System (CARS) located in the UNC Security Services Office capable of supervising fire, security, equipment or other system signals from any campus location. All fire, security, equipment signals shall transmit an alarm signal to this location by means of a digital communicator.

All security alarm systems and any special monitoring systems shall report to the CARS via a Digital Communicator. All fire detection and alarm systems shall report to the CARS via a dual line Digital Communicator. Equip all communicators with a locking cabinet and battery backup system. The report shall contain both alarm and trouble conditions. Fire detection and alarm systems shall report general alarm, system trouble, water flow and supervisory signal. Wire the communicator to the nearest building telephone closet using a four wire cable (2 pair, 22 gauge) in 3/4" conduit with ten feet (10') of excess at the closet end, terminated in

the communicator, and identified at both ends. The University shall connect to telephone lines. For interconnections, notify the Facilities Services Life Safety Shop to program the central receiver and perform a joint acceptance test to ensure proper operation.

K. SERVICE AND DISTRIBUTION

UNC–CH and most electrical contractors today have adopted a safety policy of no energized electrical work that requires an energized work permit per NFPA 70E. Consequently, the designer shall specify electrical service and distribution to minimize occupant impact during planned and unplanned power outages, including University and Duke unplanned power outages, future planned electrical maintenance and repair work and future new construction work. In addition, design shall minimize arc flash hazards on future electrical troubleshooting and lock-out/tag-out. To achieve this goal, the following shall be specified:

- Main Service Switchgear rated 2000 amps and larger shall have separate enclosure section for main breaker that is connected to distribution section via conduit, versus open busbars connections between main and distribution sections in a single enclosure. An arc flash in distribution section could propagate to line side of main breaker in a main section of a single enclosure, which would make the whole gear “dangerous” arc flash risk.
- Arc resistant switchgear, maintenance reduction switches, insulated busses, barriers and current limiting breakers and fuses shall be considered to reduce arc flash hazard.
- Remote racking shall be provided for rack mounted breakers.
- Main normal service equipment rated less than 2000 amp shall have separate enclosure for main breaker from distribution (preferred) or internal barriers provided to prevent inadvertent contact with line side of main breaker in service equipment and reduce arc flash propagation from load side to line side of service equipment.
- Emergency and Standby distribution equipment shall be fed from fully coordinated generator breaker that is separate from distribution feeding emergency side of transfer switch.
- A separate main normal service breaker enclosure shall be provided ahead of fire pump combination controllers, to allow fire pump controller to be disconnected from service transformer without turning off power to building and reduce arc flash hazard during required preventive maintenance and future troubleshooting.
- Motor control centers (MCC) shall only be provided where there is significant number of contactor/ starter controller motor loads to justify an MCC. Where motors are not within sight of MCC or starter controlled motors are few in number, individual combination disconnect/starters shall be considered for lower arc flash risk. MCCs shall not be utilized to server breaker fed loads, including VFDs and small panels. MCC shall not be excessively oversized for motor load served. Where used, MCC shall be constructed with barriers and insulation to reduce arc flash risk.
- Small 20 and 30-amp branch circuit breakers shall not be fed from the main service equipment or large distribution panels (typically over 800 amps).
- Penthouse distribution panels and MCCs shall be fed from the main service equipment on lower level floor versus other equipment in Penthouse.
- Breakers shall be fully coordinated in all loads with generator back-up, as these loads are considered critical.
- Normal breakers shall be fully coordinated to greatest extent possible, such that unplanned outages from system faults will be limited to smallest number of loads possible and to facilitate quick troubleshooting and repair.
- All feeder breakers rated 400 amps and larger shall be adjustable with LSI.
- Lighting and appliance panels shall have 225 amp main breakers to better coordinate with 20 and 30-amp branch breakers
- The use of smaller 208/120 volt transformers is preferred to lower arc flash risk per IEEE 1584.

- Dedicated electrical distribution from the main service and generator and receptacle outlet redundancy shall be provided in BL3 labs, animal quarters and other critical spaces. The dedicated distribution shall not feed building loads outside the critical space. All distribution equipment shall be labeled for dedicated space only. Lighting and appliance panels shall be located in critical space, except no panels shall be located in animal quarters or BL3 lab space where dressing out for animals or lab is required.

Designers shall provide copy of short circuit study with CD drawings.

Following Shop drawing approval, Designers are responsible for arc flash studies per latest edition of NFPA 70E, incident energy method per IEEE 1584, at same time as short circuit coordination study. Arc flash studies shall include all electrical distribution equipment, equipment and motor disconnects, VFDs, transfer switches, and generator bus.

Designer shall provide paper and electronic copy or report to owner to review hazard levels and coordination choices in breaker settings prior to providing to contractor for labels and breaker settings. For generator back-up loads and most normal loads, coordination is highest priority, except where hazard level would result in dangerous incident energy exceeding 40cal/cm (or PPE4). Final report and electronic copy of input file required for software used in study to be provided prior to beneficial occupancy.

Contractor shall set breakers and apply arc flash labels as directed by designer, in accordance with arc flash study, prior to energizing of any electrical equipment. Breaker settings shall be provided in the maintenance manual. Manufacturer's secondary current breaker test equipment for new service and distribution equipment with breakers that utilize secondary current test equipment shall be specified to be provided with this equipment

Service and distribution shall be sized for building demand with reasonable space for future growth. Contact UNC Electrical Distribution Systems for existing demand load on buildings being renovated or typical demand on similar buildings.

Lighting, mechanical and plug loads shall be fed from separate distribution breakers to allow separate energy analysis of these loads.

Provide normal and emergency service equipment with digital metering to measure the following on main breaker and main distribution breakers

- Voltage: Phase to neutral and phase to phase.
- Amperage: (True RMS) - each phase and neutral. Fundamental and harmonics through 19th.
- Kilowatt Demand
- Power Factor

Sub metering of distribution breakers to provide separate load and energy usage analysis of building normal and emergency lighting, motor and receptacles loads shall be required. Data shall be connected to UNC energy management system.

Grounding riser and/or detail and layout plans shall be provided in bid documents that clearly indicates separate grounding bar in each electrical closet, telecom closet, generator room and main electrical room.

Grounding electrode conductors from step down transformer shall be routed back to main grounding bar via grounding bars in each electrical closet. Routing shall not be "piggy backed" on the telecom grounding bars.

All grounding conductors shall be labeled at each grounding bar as identified in grounding riser.

Ground system testing must be in accordance with IEEE Fall of Potential Method by qualified individuals. UNC Engineering Services must be given 7 day notice to observe test. Testing must be completed and accepted by Engineering Services before service conductors are connected to service (utility) transformer. Copy of test report is to be submitted to Engineering Services.

System ground test shall not exceed 5 ohms. Location of test well to be documented in as-built drawings and maintained accessible at end of project.

Mount one copy of the electrical riser diagram near the main normal and emergency main service equipment in the M.E. Rooms under clear protective material. For partial renovations an updated copy of the complete electrical riser shall be provided in plans and mounted in main switchgear room by contractor.

L. PANELS

Panels that could accept future plug-in or piggy-back style breakers shall not be accepted. All current carrying components shall be copper. Lighting and Appliance panels shall be provided with hinged covers. Where available, hinge covers are preferred for distribution panels as well.

Steam and water piping shall not be located above NEC dedicated space to structure over panel. Use of shield to protect panel from leaks is not allowed.

Do not install single phase panels in a three phase system. Panels shall only serve loads on floor where they are located, unless agreed to by UNC Engineering Services.

Panel boards serving power loads in office, computer facilities, and laboratories shall have full size neutral with neutral and grounding bars sized to accommodate individual neutrals and equipment grounding conductors.

Design distribution panel boards for laboratory spaces to allow for 66% growth (e.g. 40% space breaker slots). Other panel boards shall allow at least 50% growth (e.g. 34% spare breaker slots). In this regard, the spare breaker slots are very important. Use of 42 circuit panel boards is required.

Spare demand capacity of distribution and panel boards shall be not less than 25%.

Panel boards shall not be located inside laboratories. All 480/277 panels shall be located in closets, where not accessible to public. Subpanels rated 208/120 V, 225 amps and smaller may be installed in corridors where all interested parties agree exit egress can be maintained during maintenance and emergency troubleshooting operations on energized panel. Coordination of panel locations with corridor doors shall be considered early in design to maintain this egress. Where 120/208 subpanels are in corridors, they shall be served from transformers rated less than 125 KVA or other method provided to achieve arc flash boundary that does not preclude egress. Where flush or corridor panels are approved, a spare 1 in. conduit shall be stubbed out and capped for every three spaces or spare circuits remaining in panel. These spare conduits shall be stubbed out above ceiling in the space where the panel is located.

Upon completing the installation, the electrical contractor shall conduct an electrical load balance test. Panel phases shall be balanced within 10%. Copy of all test results shall be included in maintenance manuals.

M. TRANSFORMERS, DRY TYPE

1. General

Dry type transformers shall be NEMA TP-1 rated, tested per NEMA TP-2 and labeled per NEMA TP-3.

If a large amount of non-linear load is expected anticipated on transformer, then harmonic mitigating transformers may be specified. In buildings with sensitive electronic equipment and/or an anticipated large amount of non-linear load, other harmonic mitigation equipment may be considered. Acceptable method of mitigating harmonics shall be determined early in design with all interested parties.

Transformers 15KVA and larger shall have a minimum of 6-2.5% full capacity primary taps for 480V primaries.

2. Construction

Transformers shall be common core construction. Transformers utilizing more than one core, or Scott T-connections, are not acceptable. Transformer sizing shall be based on 80 deg. C rise, with transformer constructed with 220° C insulation. Ventilation shall be by natural convection. Supplemental fans are not allowed. Transformer inrush shall be coordinated not to exceed adjustable rating on breaker feeding transformer.

N. INTERIOR LIGHTING LUMINAIRES

Day lighting shall be incorporated to the greatest extent possible in all applications and combined with daylight and occupancy sensors to minimize the use of electric lighting and reduce building cooling load. Where fluorescent tubes are provided without dimmers, inboard/outboard systems should be incorporated to provide greater lighting flexibility. Minimum ambient lighting levels should be coupled with task lighting as needed.

Preference in choosing luminaire type shall be given to luminaire types with higher efficacy. Minimum efficacy typically available for a luminaire type shall be specified. Life cycle cost analysis (LCCA) for current and new lighting technologies shall be agreed to with Facilities Services prior to DD submittal. LEDs shall be considered in LCCA.

LEDS shall be bid as base bid or alternate where supported by LCCA or where simple payback is less than 10 years on projects not requiring LCCA. Where dimming and/or interior daylight harvesting is specified, the LCCA shall consider the complete lighting system, including luminaire type plus dimming controls.

Comply with Energy Efficient Lighting Guidance Document for New Construction and Retrofits: State of the North Carolina for LED lighting with additional UNC criteria: Mock ups and/or owner witness of LED installation with same luminaire is recommended due to difference in perception from other traditional lighting sources and to confirm quality of light specified is acceptable. Circuit loads should not exceed 50% for LED fixtures. Specified LED general illumination luminaires must have full photometric report in compliance with IESNA LM 79 and be used in designer's layout design. In addition, LM 80 and TM21 end-of-life data is used for LCCA. Separate replacement of LED driver and lamps shall be possible. A minimum 5 year comprehensive warranty on LED lamp and driver is required. Where 2 or more manufacturers have 10-year warranty available for type of fixture specified, the 10-year warranty shall be specified. Recessed 2x4 and 2x2 fixtures shall be specified with 10-year warranty.

Electronic ballasts shall have input current Total Harmonic Distortion not exceeding 10%. Where available, ballasts that are rated for multiple lamp wattages shall be specified. LED drivers shall have Total Harmonic Distortion not exceeding 20%.

Use 277V for lighting where 480/277V is available, except track lighting is not required to be 277V. Do not mix 120V and 277V in a building for other general lighting applications for safety considerations. Do not install 120 volt track and 277 volt general lighting in same switch or junction boxes.

Luminaire enclosures shall be designed with acrylic or other UL approved plastics. Glass globes are not acceptable in any application. Do not use "egg-crate" louvers. Linear pendant hung luminaires shall be specified with slots/openings to allow air flow through the luminaire to reduce dust build-up that results in significant lumen depreciation. Linear fixtures shall be modular in design, such that fixtures are capable of being field-converted to individual 8 foot lengths or connected end-to-end, with manufacturer provided end caps and associated hardware.

General illumination luminaires shall be provided with integral disconnects, except where remote switch control is provided for a single luminaire. Integral disconnects must be reusable after ballast replacement.

All fluorescent lamp types specified shall be available on State Contract. See https://ncdoa.s3.amazonaws.com/s3fs-public/documents/files/285b.pdf. **Extra Long Life T8** or compact fluorescent lamps are preferred and supported by LCCA.

Incandescent lighting is not allowed at UNC-CH unless special application approval is obtained from the UNC Energy Manager.

1. Lighting Level Guidelines

Lighting designs shall conform to the recommendations of the Illuminating Engineering Society Lighting Handbook. Specific foot-candle level goals for spaces shall be agreed to by interested parties no later than Design Development submittal. Where needed, task lighting can be added to systems furniture.

2. Interior Lighting Control

ASHRAE 90.1-2014 shall be utilized for lighting control design to greatest extent possible, including daylight harvesting controls as required by standard.

Specify completion of lighting control commissioning in space and owner and occupant training prior to beneficial occupancy.

Appropriate automatic cutoff for interior lighting per ASHRAE 90.1 shall be discussed during schematic design phase and agreed to by all interested parties no later than Design Development submittal. Wall mounted occupancy sensors shall not be blocked by furniture. Switch located occupancy sensors shall only be used in small single occupancy spaces.

Provide for local occupant control in occupant accessible location for all spaces, including corridors and spaces controlled by occupancy sensors, that allows for occupant to turn off lights when leaving space.

Vacancy sensors shall be used versus occupancy sensors. Infrared vacancy sensors shall be located where they cannot be block by furniture arrangement. Wall mounted sensors shall only be used in place of toggle

switches in small single occupant spaces. Specify for manufacturer submittal to show sensor location and space coverage of sensors on layout plans.

In lengthy open office areas, provide separate lighting control for every four or five workstations. Master control in suite areas should be considered for spaces with regular office hours.

Where dimming is provided, dimming system shall be capable of interfacing with photocells, time clocks and occupancy sensors for additional automatic cut-off of lights.

Dimming control of LEDs shall be confirmed by luminaire manufacturer as compatible and as providing desired low end of dimming without flicker and with load specified.

Provide local control capable of dimming or capable of reducing lighting levels by 1/2 and 2/3 in all building areas, except in corridors, MEP closets and other areas as agreed to with the Project Manager.

Designer shall consider using photocells and dimmable ballast in perimeter rooms to turn off lights when the available daylight augments the lighting level.

3. *Lighting Fixture Applications*

All applications where occupants use visual display terminals only use indirect lighting luminaires, indirect linear and/or pendant types with multiple switching or dimming capabilities. For example:

- General offices
- Classrooms
- Laboratories
- Lab benches
- Locate a fixture over the edge of each lab bench on each side of the aisle
- Use batwing or bilateral lenses for under-cabinet or shelf-hung luminaries

For all new construction and renovation projects that require lighting fixture replacement, use luminaires with T-8, compact fluorescent or LED lamps.

4. *Lighting of Large Interior Areas*

Use LED, metal halide or fluorescent lighting for all warehouses. For gymnasium, atriums and similar high ceiling applications where a lift would be required for maintenance, use LED luminaries. Design shall conform to the recommendations of the Illuminating Engineering Society of North America (IESNA) Lighting Handbook. Interior high lumen output LED luminaries replacing metal halide lights shall provide heat dissipation from enclosure through convection. Fans are not allowed.

5. *Lighting Maintenance Considerations*

The lighting design must address accessibility for re-lamping, cleaning and other maintenance procedures. Mounting heights of interior fixtures in stairways shall be at 8 feet and not over 12 feet in other spaces unless agreed to by UNC Engineering Services.

Fixture locations requiring scaffolding or rented lifts to maintain lamps and ballasts shall be avoided. In spaces with fixed seating, where ladders and lifts cannot be used, fluorescent or self-driven LED lamps that

can be changed with a lamp pole from ground level shall be used As an alternative, fixture lowering means or catwalk shall be provided for maintenance of fixtures. Provide same accessibility in atrium areas not accessible by lift and/or long throw asymmetric light fixtures, mounted in all locations accessible by a 20 foot ladder.

Spare parts shall include the following:

- 1% of each type of ballast or LED driver except for T8, T17 and compact fluorescent ballasts
- 2 of each type of LED light engine
- 10% of each type of specialty lamp, does not include T8, T17 or compact fluorescent lamps
- 10% of each type of occupancy sensor
- 2% relays and 1 extra circuit board for each type of lighting control panel
- Specialty non-metallic fixture lens covers – quantity determined per project

6. Exit and Egress Lights

Where a battery provides the emergency back-up, the luminaire shall be self-diagnostic. Centralized battery back-up versus individual battery back-up shall be agreed upon by UNC Engineering Services during the design. Where emergency generator back-up is available, battery back-up shall not be added, unless agreed to by UNC Engineering Services and UNC Electrical Maintenance. The transfer switch for emergency exit and egress lighting shall be separate from the emergency manifold fume hood and associated make-up air transfer switches.

O. CLASSROOMS FOR MULTIMEDIA PRESENTATIONS

The classroom lighting system must be versatile enough to provide an appropriate environment for today's audio visual technologies as well as the traditional lecture in front of a chalkboard. At the same time, the design of the lighting system must be simple enough to allow rapid and intuitive adjustment of lighting levels to suit this variety of media. All multimedia classrooms, auditoriums and conference rooms shall have lighting systems that allow for various lighting levels and control glare with highlighting features necessary to present the material.

Make provisions for dimming to enhance the use of various projected materials. Use fluorescent dimming ballasts or LED in architectural dimming applications, capable of dimming to 1% of full light output. Ballast or driver and controls must be confirmed as compatible by manufacturer testing.

Provide separate controls for appropriate luminaires to eliminate over lighting of projection screens and to provide proper highlight illumination of marker boards and lecterns.

To provide simplicity of operation, eliminate standard 3-way and 4-way switching systems. Provide programmable multiple zone, multiple scene preset, or digitally addressable (best for future flexibility in changing zones) lighting controls in all multimedia rooms. Wireless controls must be approved by UNC ITS, such that they will not interfere with wireless data in buildings. Typically 802.11 protocols are reserved for wireless data and are not allowed for lighting controls. CLASSROOMS FOR MULTIMEDIA PRESENTATIONS

All classrooms visual display terminals only use indirect lighting luminaires, indirect linear and/or pendant types with multiple switching or dimming capabilities. For example:

For all new construction and renovation projects, that require lighting fixture replacement, use luminaires with T-8 fluorescent lamps or LED.

P. EXTERIOR WALL MOUNTED BUILDING LIGHTING

When the need arises for mounting luminaires on an outside wall of a building, design the lighting system to ensure adequate lighting levels without creating glare or nuisance lighting into residential rooms or other areas. Mount these lights for ease of maintenance and connect to a power source in the building.

Wall mounted lighting shall be designed to be LED luminaires. Any exceptions, shall be approved by UNC Engineering Services. The fixture choice shall be a function of the campus area where lighting is to be located and compatibility to existing lighting in the surrounding areas in style, color and function. For areas being provided with new site lighting refer to Electrical Utilities Site Lighting Section of these guidelines for additional information.

Lighting should be designed to reduce light pollution to the night sky. Building wall mounted units should provide only down lighting. For more details on light pollution and light trespass, see the Illuminating Engineering Society of North America's Recommended Practices for outdoor lighting (IESNA RP-33) or reference the presentation by the Northwest Energy Efficiency Alliance and the Lighting Design Lab.

Exterior exit and egress lighting shall be powered by the same type of emergency backup as provided for interior exit and egress lighting.

Q. TELECOMMUNICATIONS

Basic telecommunications requirements for all new structures include service entrance ducts, telecommunications rooms, a conduit riser system between floors, a floor cabling distribution system, and building horizontal and riser cabling. Qualified Communications Contractors shall be required to procure, terminate, test and provide documentation for telecommunications wiring as specified by the UNC-CH Telecommunications Office. For general design requirements refer to web site:

http://its.unc.edu/about-us/what-we-do/communication-technologies/communication-technologies-engineering/

The information found at the aforementioned web site is NOT intended to be a Telecommunications performance specification. Each project designer will be expected to write a performance specification for the Telecommunications work on each project.