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:
  - Underwriters Laboratory (UL)
  - Institute of Electronic Engineers (IEEE)
  - Illuminating Engineering Society of North America (IESNA)
  - National Fire Protection Association (NFPA)
  - National Electrical Manufacturers Association (NEMA)
  - American National Standards Institute (ANSI)
  - North Carolina State Construction Office Electrical Guidelines: http://www.nc-sco.com/documents/guidelines/2011_Electrical_Guidelines.pdf
  - 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, Department of Insurance prior to approval for final payment and before energizing any new transformers and electrical service.

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

3. Equipment Identification

All equipment shall be properly identified with equipment identification, equipment controlled, panel and circuit feeding equipment, electrical ratings and date of installation.

4. Electrical Systems 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.

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.

5. Acceptance Criteria

After completion of specified training, the Contractor shall conduct the specified operation acceptance test, witnessed by the Owner's representative. Contractor shall submit copies of reports documenting all specified tests to owner.

B. WIRE AND CABLE

- Branch circuits serving 120/208, multi-outlet receptacles shall not require greater than No. 10 wire to comply with maximum 3% voltage drop requirement. 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 of furniture feed for receptacles and telecommunication outlets with owner and furniture vendor.
- 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. 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. Specify in bid documents that conduit is not to be run in building slab except where specifically indicated in drawings.

D. OUTLET 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.

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.

E. WIRING DEVICES

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

Junction boxes shall be labeled with panel and circuits contained.

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

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. Separate feed to generator and dedicated transfer switch is required for all BL3 lab loads.

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.

Contact Life Safety Group to obtain a guideline document with complete UNC and State Construction requirements for designer's use in their performance specifications. 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. Products of firms that do not maintain factory authorized service organization and spare parts stock 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 specified. These preferred alternates shall be 1) ASCO without http connectivity without bypass isolation and 2) ASCO with http connectivity, as described below. ASCO 4000 or 7000 are preferred.

Acceptable generator manufacturers who have agreed to the provide factory training/certification to UNC are CAT 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 operators 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 1.3.A above.

- 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. If over 24" high access to the controller must be provided.

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.

8. *Outdoor Enclosure*

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

9. *Interior Locations*

Generator Rooms, in buildings, shall have sealable floor drains to facilitate clean-up with a water supply within 50'.

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 power outlet for maintenance use.

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 loads. 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. Closed transition transfer switch is optional, to be determined during design with building representative.

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 (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

1. Quality Assurance

Provide warranty period for VFDs and any bypass for 18 months minimum, inclusive of parts, travel, labor and shipping required for repair from date of startup

The power converter section of every VFD shall be tested with an actual AC induction motor while loaded and temperature cycled within an environment chamber at 40˚ C (104˚ F).

Power line conditioning shall be provided for VFDs.

2. Products

If more than one VFD is included in this project, all VFDs shall be products of the same manufacturer, VFDs shall be by Square D Company, Class 8839, Type ATV-56, or equivalent as manufactured by ABB, or Danfos-Graham.

The manufacturer must provide to the University, on digital disk, the programming software which will enable the University service personnel the use of a laptop computer to set up any and all of the parameters of the drive. The software must provide all the capabilities which are provided by the unit keypad as a minimum. The drive must be equipped with all equipment and software to accommodate laptop connection.

The manufacturer must ensure the University service personnel has unlimited access to the manufacturer's technical support staff.

The VFD shall include a power converter to convert the input AC power to an adjustable frequency and voltage, as defined in the following sections.

The input power section of the power converter shall utilize a full wave bridge design incorporating diode rectifiers. The diode rectifiers shall convert fixed voltage and frequency AC line power to fixed DC voltage. This power section shall be insensitive to phase rotation of the AC line.

The output power section of the power converter shall change fixed DC voltage to adjustable frequency AC voltage, utilizing insulated gate bipolar transistors (IGBTs).

Pulse type VFDs shall be a minimum 12 pulse type where significant VFD load is present on an emergency generator or in other sensitive electronic equipment environment. As an alternative, harmonic mitigation that limits Total Harmonic Distortion to 5% maximum based on IEEE 519 analysis may be specified. Design specifications for the acceptable mitigation method(s) will be discussed and agreed to with all interested parties during design.

3. Construction

The VFD shall be composed of the power converter section and the associated combination enclosure, and each shall be housed in NEMA Type-1 enclosures. Both shall be mounted on a single panel, with the power converter section mounted above the combination enclosure. VFDs shall not be installed in motor control centers.

The combination enclosure shall provide dedicated user terminals for power and control device connection. It shall include the disconnect, current limiting fuses, operator controls, user terminal strip connections, and bypass controls and contactors. User power termination within the power converter section is not acceptable.

Provisions shall be included for padlocking the disconnect in the OFF position.

Current limiting fuses shall be wired to the power converter input, and shall be installed in the combination enclosure.

The power converter section shall include an internal cooling fan (with dual ball bearings), with a MTBF rating of at least 40,000-hours.

4. Application Data

The VFD shall be sized to operate a Variable Torque load.

The speed range shall be from a minimum speed of 1.0 Hz to a maximum speed of 72 Hz.

- Environmental Ratings
  - The VFD shall be designed to operate in a pollution Degree-2 environment. The VFD shall meet IEC 664-1 and NEMA ICS 1 Standards.
  - The storage temperature range shall be -25˚ C to 70˚ C (-13˚ F to 158˚ F).
  - The maximum relative humidity shall be 95% at 40˚ C (104˚ F), non-condensing.
  - The VFD shall be rated to operate at altitudes less than or equal to 3,300 ft. (1000m). For altitudes above 3,300 ft. (1,000 m), de-rate the VFD by 1.2% for every 330 ft. (100m).
  - The VFD shall meet the IEC 68-2 operational vibration specification.

- Performance Ratings
  - The VFD shall be designed to operate (±) 10% of rated voltage
  - The VFD shall operate from an input frequency range of 47.5 to 63-Hz.
  - The displacement power factor shall not be less than 0.95 lagging under any speed or load condition.
  - The efficiency of the VFD at 100% speed and load shall not be less than 96%.
  - The variable torque rated VFD over current capacity shall be not less than 110 % for 1-minute.
  - The output carrier frequency of the VFD shall be programmable at 2, 4 or 10-kHz. In addition, the output carrier frequency shall be randomly modulated about the selected frequency. VFDs with an operable carrier frequency above 10-kHz shall not be allowed.

- Protection
  - Upon power-up, the VFD shall automatically test for valid operation of memory, loss of analog reference input, loss of communication, DC-to-DC power supply, control power and pre-charge circuit.
  - The VFD shall be UL 508C listed for the available fault as determined available by the designer, but no less than 22,000-A rms fault current for 460 V drives. For 208-VAC distribution systems, the UL508C listing shall be for 8,800-A rms of minimum available fault current. The Power Converter shall meet the short circuit specifications defined by NEMA ICS 7.1.09, and have the value listed on the VFD nameplate.
  - The VFD shall be protected against short circuits between output phases and to ground.
  - The VFD shall have a minimum AC undervoltage power loss ride-through of 200 milliseconds (12 cycles).
  - The VFD shall have a programmable ride through function which will allow the logic to maintain control for a minimum of one second (60 cycles) without faulting.
  - For a fault condition other than a ground fault, short circuit or internal fault, an auto restart function will provide up to 5 programmable restart attempts. The programmable time delay before restart attempts will range from 1 second to 600 seconds.
  - Upon loss of the analog input speed reference signal, the VFD shall fault and / or operate at a user-defined speed set between programmed low- and high-speed settings.
  - The VFD shall include solid-state protection that is UL listed and that meets UL 508 C as a Class 10 overload protective device and meets IEC 947. The minimum adjustment range shall be from .45 to 1.05% of the current output of the VFD.

- The output frequency shall be software -controlled to reduce frequency (fold back) when the motor is overloaded.
- There shall be three skip frequency ranges that can each be programmed to a bandwidth of 2 or 5 Hz. The skip frequencies shall be programmed independently, back to back, or overlapping.
- The VFD shall include 'output phase imbalance' fault indication.

- Adjustments & Configurations

  - The VFD will be factory programmed to operate all specified optional devices.
  - The acceleration and deceleration ramp times shall be adjustable from 1 to 999 seconds.
  - The memory shall retain and record run status and fault type of the past 8 faults.
  - The software shall have a no load function that, when selected, will reduce the voltage to the motor for variable torque loads. A constant volts/Hz ratio will be maintained during acceleration. The output voltage will then automatically adjust to meet the torque requirement of the load.

- Keypad Display Interface

  - The keypad display interface shall enable adjustments to the VFD via a touch keypad. All electrical values, configuration parameters, I/O assignments, application and activity function access, faults, local control, adjustment storage, self-test and diagnostics shall be in plain English.
  - The display will be a high resolution, LCD back-lit screen capable of displaying graphics such as bar graphs as well as six lines of 21 alphanumeric characters.
  - The VFD model number, torque type, software revision number, horsepower, output current, motor frequency and motor voltage shall be listed on the drive identification portion of the LCD display.
  - The keypad display shall be configured to display one or two bar graphs with numeric data that are programmable by the operator. As a minimum the programmable outputs shall consist of speed reference, output frequency, output current, motor torque, output power, output voltage, line voltage, DC voltage, motor thermal state, drive thermal state, elapsed time, motor speed, machine speed reference and machine speed.
  - The keypad display shall consist of programmable function keys that allow both operating commands and programming options to be preset by the operator. A hardware selector switch shall allow the terminal keypad to be locked out from unauthorized personnel.
  - A RUN key and a STOP key will command a normal starting and stopping as programmed when the VFD is in keypad control mode. The STOP key must be active in all control modes.
  - The VFD shall have three LEDs mounted on the front panel to indicate functional status. A green LED will verify that the VFD power supply is on. A red LED indicator will indicate a VFD fault. A yellow LED indicator will designate a pending fault condition.

5. Operator Control Interface

The control power for the digital inputs and outputs shall be 24 VDC.

The internal power supply shall incorporate automatic current fold-back that protects the internal power supply if incorrectly connected or shorted. The transistor logic outputs will be current limited and will not be damaged if shorted.

Pull-apart terminal strips shall be used on all logic and analog signal connections in the power converter.

Input requirements; four isolated digital logic inputs and two isolated analog inputs (one 0 - 10VDC speed potentiometer and one 4-20mA speed reference).

Output requirements; two digital logic outputs, two voltage-free relay output contacts (fault status and a programmable drive run), and two isolated 4 – 20 mA analog outputs that can be selected and assigned in the software (and be proportional to the following motor characteristics: frequency, current, power torque, voltage and thermal state).

The combination enclosure shall have the following dedicated operator controls:

- Hand-Off-Auto switch
- Manual Speed Potentiometer
- VFD-Off-Bypass switch
- The hands-off-auto function which provides seamless transfer from EMCS control to hand control and back, without interruption of motor speed on transfer...

The optional 120 VAC smoke purge relay shall be installed in the combination enclosure, and shall enable the VFD to be sequenced in accordance with local fire protection codes. A user-supplied 120 VAC signal will switch the VFD to 60 Hz operation for maximum fan motor speed. If drive bypass is supplied, the smoke purge relay will isolate the VFD and run the fan motor full speed on bypass

The combination enclosure shall also include terminal point connection for fire /freeze stat interlock, to prevent drive or bypass [if supplied] operation.

VFDS shall be furnished with a LonTalk compatible FTT-10A compatible transceiver

6. Drive / Bypass Contractors

VFS with bypass mode shall a drive disconnect, a two contactor bypass for full speed operation, and isolation barriers between the VFD and bypass. Specify VFDs with bypass when installed on pump or fan motors.

The combination enclosure shall include a pair of IEC rated bypass contactors (complete with thermal overload relays) to isolate the VFD output during the bypass mode and to coincidentally provide line power directly to the motor. It shall also include: fuses on the line side of the VFD to enable isolation, a circuit breaker disconnect, control circuit transformer, motor flux decay timer and VFD/OFF/BYPASS switch. The operator shall have full control of the bypass contactors by operation of the combination enclosure mounted selector switch. The bypass contactors shall be in the same enclosure as the drive.

7. Execution

Do not install the VFD until the building environment can be maintained within the service conditions required by the manufacturer.

Do not install the VFD in the air handling unit.

Provide individual VFDs located adjacent to motor served. Before and during the installation, the VFD shall be protected from site contaminants.

The VFD manufacturer shall provide a factory certified technical representative to inspect the contractor's installation, and to test and start-up the VFDs furnished under this specification for a maximum total of

ONE-HALF day per VFD. All pilot devices shall be tested to verify proper operation. Documentation shall be furnished.

8. Training

A one-day on-site training course shall be provided by a representative of the VFD manufacturer to plant and/or maintenance personnel.

9. Documentation

The VFD manufacturer shall supply a comprehensive 8-1/2" x 11" spiral bound instruction-installation manual that includes wiring diagrams, layout.

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

Designers shall provide copy of short circuit study with CD drawings. Where distribution equipment contains breakers sizes exceeding 10 times the potential arc flash current, maintenance switches or other methods for reducing arc flash potential shall be considered to reduce required arc flash PPE to 2 or less. Motor control centers shall provide barriers in buckets to vertical buses and other means to reduce PPE to 2 or less.

Designers shall perform arc flash studies per 2009 NFPA 70E at same time as short circuit coordination study during shop drawing approval. Designer shall provide paper and electronic copy to owner to confirm proper arc flash labeling and setting of adjustable breakers during final walk-through. Electronic copy shall be provided in input format required for software used in study, to be used in future updates to distribution system.

Arc flash studies shall include all electrical distribution equipment, including disconnects for HVAC equipment. Arc flash analysis is not required for 120/208V equipment on the secondary side of transformer rated 125KVA or less.

Manufacturer’s secondary current breaker test equipment for new service and distribution equipment with breakers that utilize secondary current test equipment shall be specified as provided with this test 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.

Equip main distribution panel with digital metering to measure the following:

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

Submetering to provide separate load and energy usage analysis of building normal and emergency lighting, motor and receptacles loads shall be required.

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.

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

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 switchgear in the M.E. Room 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 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 all interested parties.

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 panelboards 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 panelboards is preferred.

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 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 in above ceiling space.

Upon completing the installation, the electrical contractor shall conduct an electrical load balance test. Panel phases shall be balanced within 10%.

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 K –rated transformers may be specified. Do not specify transformers with K rating greater than 13. In buildings with sensitive electronic equipment and/or an anticipated large amount of non-linear load, harmonic mitigation shall 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 deg. C insulation. Ventilation shall be by natural convection. Supplemental fans are not allowed.

Sound levels shall be guaranteed by the manufacturer not to exceed the following:

- K-4 rating: 15 to 50 KVA - 45 dB; 51 to 150 KVA - 50 dB; 151 to 300 KVA - 55 dB; 301 to 500 KVA - 60 dB
- K-13 rating: 15 to 50 KVA - 43 dB; 51 to 150 KVA - 47 dB; 151 to 300 KVA - 52 dB; 301 to 500 KVA - 57 dB

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 for current and new lighting technologies shall be agreed to with Facilities Services prior to DD submittal. LED general illumination luminaires may also be considered where supported by life cycle cost analysis provided a full photometric report in compliance with IESNA LM 79 is utilized in designer's layout. In addition, LM 80 and TM21 end-of-life data is available 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.

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.

Use 277V for lighting where 480/277V is available, except track lighting is not required to be 277V. Do not mix 120V and 277V for lighting applications for safety considerations.

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 lamp types specified shall be available on State Contract, with the exception of general illumination LED luminaires. See http://www.doa.state.nc.us/PandC/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 90.1-2010 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.

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 metal halide or fluorescent lighting for all warehouses. For gymnasium and similar applications, use metal halide luminaries. Design shall conform to the recommendations of the Illuminating Engineering Society of North America (IESNA) Lighting Handbook.

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 all interested parties.

Fixture locations requiring scaffolding or rented lifts to maintain lamps and ballasts shall be avoided. In spaces with fixed seating, where ladders are difficult to use, self-ballasted fluorescent or self-driven LED lamps that can be changed with a lamp pole from ground level shall be used. In atrium areas use fixture lowering means and/or long throw asymmetric light fixtures, mounted in 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
- 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 interested parties during the design. Where emergency generator back-up is available, battery back-up shall not be added, unless agreed to by all interested parties. 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 in architectural dimming applications, capable of dimming to 1% of full light output. Ballast and controls must be by the same manufacturer.

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 multiple zone, multiple scene preset, and programmable lighting controls in all multimedia rooms. For less than six zones, wireless controls shall be used.

P. 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 or T5 fluorescent lamps.

Q. 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 high pressure sodium (HPS), metal halide or LED luminaires. This 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 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 Illumination 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.

R. 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/CommTechnology/engineering_and_operations

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.