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**End of List**
PART 1 - GENERAL

1.1 SUMMARY

A. (delete if not required) [It is intended this project pursue a LEED [Gold] [Silver] rating. LEED criteria will be followed for the installation of building systems. This Contractor shall be responsible for the following items to ensure the Facility achieves LEED certification:

1. SS credit 8 – Light Pollution Reduction.
2. EA prerequisite 2 – Minimum Energy Performance.
4. MR credit 2 – Construction Waste Management.
5. IEQ credit 4.1 – Low Emitting Materials: Adhesives and Sealants
7. IEQ credit 6.1 – Controllability of Systems: Lighting.]

B. Section Includes:

1. Common electrical installation requirements.

1.2 SUBMITTALS

A. N/A.

PART 2 - PRODUCTS

2.1 N/A.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with Northwestern University Design Guidelines.

B. (Select based on project location) [Comply with City of Chicago Codes and Standards.] [Comply with City of Evanston Codes and Standards.]

C. Comply with NECA, NFPA, and OSHA requirements.

D. All work shall be installed in a neat, workmanlike manner in accordance with ANSI/NECA 1 – 2015.
E. All materials and equipment provided under this contract shall be new (except where otherwise noted) and shall be listed, labeled or certified by a Nationally Recognized Testing Laboratory (NRTL) to meet Underwriters Laboratories, Inc. (UL), standards where test standards have been established. Materials and equipment which are not covered by UL standards will be accepted, providing that materials and equipment are listed, labeled, certified or otherwise determined to meet the safety requirements of a NRTL.

1. A Nationally Recognized Testing Laboratory is a testing laboratory which is recognized and approved by the Secretary of Labor in accordance with OSHA regulations.

F. All materials, products, and equipment being installed which fall into a category covered by the ENERGY STAR® program shall be provided and labeled as such.

G. All equipment of the same type and capacity shall be by the same manufacturer.

H. Keying: All panel doors in electrical equipment shall be equipped with Corbin Access Systems key cylinders with removable cores. Coordinate with University Electric Shop.

I. Where any device or part of equipment is referred to in these specifications in the singular number (e.g., “the switch”), this reference shall be deemed to apply to as many such devices as are required to complete the installation as shown on the drawings.

J. During construction the contractor shall at all times maintain electrical utilities of the building without interruption. Should it be necessary to interrupt any electrical service or utility, the contractor shall secure permission in writing from the University’s Chief Electrician for such interruption at least ten (10) business days in advance. Any interruption shall be made with minimum amount of inconvenience to the University and any shut-down time shall have to be on a premium time basis and such time to be included in the contractor’s bid. Arrange to provide and pay for temporary power source as required by project conditions.

K. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounted items.

L. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements and shall be coordinated with NU Electric Shop.

M. Working clearance around equipment shall not be less than that specified in the N.E.C. for all voltages specified.

N. The locations of switches, receptacles, lights, motors, etc. outlets shown are approximate. The contractor shall use good judgment in placing the preceding items to eliminate all interference with ducts, piping, etc. The contractor shall check all door swings so that light switches are not located behind doors. Relocate switches as required, with approval from the Design Professional. The University may direct relocation of outlets before installation, up to five (5) feet from the position indicated on the Drawings, without additional cost.

O. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity. Normal maintenance shall not require the removal of protective guards from adjacent equipment. Install equipment as close as practical to the locations shown on the Drawings.
1. Where the University’s Chief Electrician determines that the Contractor has installed equipment not conveniently accessible for operations and maintenance, the equipment shall be removed and reinstalled as directed at no additional cost to the University.

2. “Conveniently Accessible” is defined as being capable of being reached without climbing or crawling over or under obstacles such as motors, pumps, belt guards, transformers, racks, piping, ductwork, raceways or similar.

P. Right of Way: Give to piping systems installed at a required slope.

Q. Firestopping shall be applied to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of the assembly according to Division 07 and 09 Sections and the University Fire Protection Standards.

R. Owner furnished equipment: Equipment furnished by the University shall be received, stored, uncrated, protected, and installed by the Contractor with all appurtenances required to place the equipment in operation, ready for use. The Contractor shall be responsible for the equipment as if he had purchased the equipment himself and shall hold the warranty.

END OF SECTION 26 0500
COMMON WORK RESULTS FOR ELECTRICAL WORK 26 0500 - 4
SECTION 26 0501 – GENERAL ELECTRICAL REQUIREMENTS for RENOVATION and DEMOLITION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes general requirements for renovation and demolition of electrical systems and materials for all Campus buildings and facilities.

   1. (Future use).

B. (Future use):

   1. (Future use).

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 SUBMITTALS

A. N/A.

PART 2 - PRODUCTS

2.1 N/A.

PART 3 - EXECUTION

3.1 REQUIREMENTS FOR ELECTRICAL RENOVATION AND DEMOLITION

A. Comply with Northwestern University Design Guidelines.

B. (Select based on project location) [Comply with City of Chicago Codes and Standards.] [Comply with City of Evanston Codes and Standards.]

C. Comply with NECA, NFPA, and OSHA requirements, NEC-70 and -70E.

D. The University may occupy portions of the building immediately adjacent to the area of demolition. Arrange demolition so as not to interfere with University's operations.

E. Protect adjacent building services and materials indicated to remain. Install and maintain barriers to keep dirt, dust and noise from being transmitted to adjacent areas. Remove
protection and barriers after demolition is completed. If infiltration of dust or dirt results due to improper barriers, Contractor shall be responsible for all maintenance and cleaning.

F. Where electrical work to remain is damaged or disturbed in the course of the work, the Contractor shall remove damaged portions and provide new products of equal capacity, quality, and functionality at his own expense.

G. Unless otherwise noted, demolish and remove existing electrical materials and equipment only to the extent required by new construction and as indicated. Removal of equipment shall not interfere with existing operations.

H. Notify Architect of discrepancies between existing conditions and the Drawings before proceeding with demolition or renovation.

I. During construction the contractor shall at all times maintain electrical utilities of the building without interruption. Should it be necessary to interrupt any electrical service or utility, the contractor shall secure permission in writing from the University's Chief Electrician for such interruption at least ten (10) business days (or two calendar weeks) in advance. Any interruption shall be made with minimum amount of inconvenience to the University and any shut-down time shall have to be on a premium time basis and such time to be included in the contractor's bid. Arrange to provide and pay for temporary power source if required by project conditions. If requested by NU Electric Shop, power may be metered. Submit drawing of proposed temporary connections for approval.

1. Services passing through areas of remodeling shall be maintained throughout the construction period.
2. Circuits serving areas adjacent to the construction area that are modified as part of a remodeling project shall be re-circuited as part of the project.
3. Provide temporary and/or modify existing emergency power, emergency lighting, fire alarm, and other services as required for construction-period Life Safety measures. Submit proposed plan to NU Electric Shop.

J. Contractor shall ensure that light switches within the Work area remain operational. Where temporary 120 volt light strings are installed, a switch shall be provided for the light strings near the Project entry door. Lights shall be switched off every day at the completion of the shift.

K. Turn off circuit breakers or switches serving abandoned circuits at the commencement of work and tag breaker or switch and label in panel schedule as “Spare”.

L. Remove conduit and wire back to panelboards or to nearest junction box that is not being removed and needs to remain in service. Wire shall be removed back to point of origin.

M. Conduit and Junction Boxes:

1. Conduit and boxes in existing walls to be demolished shall be removed.
2. Conduit and boxes in existing walls to remain (if not reused) shall be removed.
3. Conduit in existing or new ceilings that is not intended for reuse shall be removed back to the panel from where it originates.
4. Conduits that had been run in existing slabs shall be saw-cut off flush where they exit the slab and then be fire-sealed.

N. Conductors:
1. Conductors that are not to be reused shall be removed back to the nearest point-of-use. Where the entire circuit is to be removed, the conductors shall be removed back to the panelboard from which they originate.

O. Receptacles:

1. Remove devices that are not installed at reusable locations. Boxes shall be blanked.

P. Lighting Fixtures:

1. Lighting fixtures that cannot be reused shall be removed, including associated wiring to ceiling-mounted junction boxes.
2. Fluorescent lighting fixtures shall not be reused or relocated and shall be replaced with LED types per Section 265100 requirements.

Q. Relocation: Carefully remove, clean and restore items designated for relocation to a “like new” condition, and store them for reuse.

R. Materials and equipment to be removed, except items specifically noted to be relocated or delivered to the University, become property of the Contractor and shall be immediately removed from the Project Site and legally disposed of. If the University identifies other items during construction, those items become University property and shall be turned over to the University. All salvaged items belonging to the University shall be stored in a secure area until delivery to University as directed. Transport all such items to University's designated storage area.

S. Demolished items, rubbish and debris shall be removed from the construction site daily, and at the completion of the work. Floors shall be swept clean daily. Failure to do so may result in the cleanup being performed by others and all costs thereof being deducted from the Contractor’s final payment.

T. All tools and ladders shall be locked up at the end of the work every day.

END OF SECTION 26 0501
SECTION 26 0513 - MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
A. This Section includes medium voltage shielded power cables, sizes 1/0 through 2000 kcmil, related splices, terminations, and accessories for medium-voltage electrical distribution systems, nominal 2.4 kV through 15 kV services.

1.3 DEFINITIONS
B. AIA: Aluminum Interlocked Armor.

1.4 ACTION SUBMITTALS
A. Product Data: For each size and type of cable indicated.
B. Samples: 16-inch (400-mm) lengths of each type of cable indicated.
C. Include data sheets for the following additional items:
   1. Splices and terminations.
   2. Separable connectors.
   3. Cable accessories.
   4. Pulling compounds.
   5. Strand dynamometer.

1.5 INFORMATIONAL SUBMITTALS
A. Resumes of cable splicer(s).
B. Material Certificates: For each cable and accessory type, signed by manufacturers.
C. Cable pulling tension calculations and recorded values.
D. Source quality-control test reports.
E. Field quality-control test reports.
1.6 QUALITY ASSURANCE

A. Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable. Cable splicer shall have a minimum of 2000 hours experience with terminating and installing medium voltage cable. Furnish satisfactory proof of such experience for each employee who splices or terminates the cables prior to any work. Submit names and service dates of proposed employees. Persons listed by the Contractor may be required to perform a dummy or practice splice and termination in the presence of the Electrical Shop representative and Engineer before being approved as a qualified installer of medium-voltage cables.

B. Source Limitations: Obtain cables and accessories through one source from a single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with IEEE C2 and NFPA 70.

E. Comply with ASTM B3 and B8.

F. NRTL (Nationally Recognized Testing Laboratory) Listing: Products shall be listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction for electrical and fire safety.

G. Comply with most current edition of the Northwestern University Design Standards.

1.7 PROJECT CONDITIONS (Delete If Not Required)

A. [Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by the University or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify the University’s Chief Electrician no fewer than [two] calendar weeks in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electrical service without the University’s Chief Electrician’s written permission.
3. University Lock-out/Tag-out procedures shall be used with Contractor controlled locks and tags.
4. Comply with NFPA 70E.]

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cables:
a. General Cable Technologies Corporation.
b. Okonite Company (The).
c. Southwire Company.

2. Cable Splicing and Terminating Products and Accessories:
   a. 3M; Electrical Products Division.

2.2 CABLES

A. Cable Type: [Single conductor] [Three conductor (AIA only)], UL type MV105 approved for N.E.C. applications.

B. Comply with UL 1072, AEIC CS 8, ICEA S-93-639/NEMA WC74, and ICEA S-97-682.

C. Conductor: Annealed, soft drawn Copper.

D. Conductor Stranding: Compact round, concentric lay, Class B.

E. Conductor Insulation: discharge free, no lead, Ethylene-Propylene Rubber (EPR), color contrasted with strand and insulation shields.
   2. Insulation Thickness: 133 percent insulation level.

F. Strand Shielding: Black extruded semi-conducting thermoset copolymer applied directly over the conductor.

G. Insulation Shield: Black extruded semiconducting thermoset copolymer applied directly over the insulation.

H. Shielding: [Copper tape, 5 mils thick, helically applied with 25% overlap, over semiconducting insulation shield.] or [six solid copper corrugated drain wires embedded longitudinally in composite layers of semi conducting thermoset copolymer and CPE].

I. Cable Jacket: Chlorinated Polyethylene, CPE per ICEA and UL 1072.

J. Identification: The following minimum legend shall be printed on the jacket and repeated at not more than two foot intervals.
   1. Manufacturer/plant no.
   2. Conductor size (awg or kcmil).
   3. CU.
   4. EPR.
   5. SHLD.
   6. Voltage (kV).
   7. Insulation level (133%).
   8. Insulation thickness (mils), MV-105.

2.3 SPLICE KITS

A. Connectors and Splice Kits: Comply with IEEE 404; type as recommended by cable or splicing kit manufacturer for the application.
B. Manufacturers: Subject to compliance with requirements, provide products by the following: 3M

C. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.
   2. Pre-molded, cold-shrink-rubber, in-line splicing kit.

2.4 SOLID TERMINATIONS

A. Manufacturers: Subject to compliance with requirements, provide products by the following: 3M

B. Multi-conductor Cable Sheath Seals: Type recommended by seal manufacturer for type of cable and installation conditions, including orientation.
   2. Cold-shrink sheath seal kit with preformed sleeve openings sized for cable and insulated conductors.
   3. Heat-shrink sheath seal kit with phase- and ground-conductor re-jacketing tubes, cable-end sealing boot, and sealing plugs for unused ground-wire openings in boot.

C. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class is equivalent to that of cable. Include shield ground strap for shielded cable terminations.
   1. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone rubber, insulator modules; shield ground strap; and compression-type connector.
   2. Class 1 Terminations: Heat-shrink type with heat-shrink inner stress control and outer non-tracking tubes; multiple, molded, non-tracking skirt modules; and compression-type connector.
   3. Class 2 Terminations, Indoors: Kit with stress-relief tube, non-tracking insulator tube, shield ground strap, and compression-type connector. Include silicone-rubber tape, cold-shrink-rubber sleeve, or heat-shrink plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.
   4. Medium voltage cable terminations and splices: long barrel, 2-hole hydraulic crimp lugs.

2.5 SEPARABLE INSULATED CONNECTORS

A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.

B. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.

C. Load-Break Cable Terminators: Elbow-type units with 200-A load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.
D. Dead-Break Cable Terminators: Elbow-type unit with 600-A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

E. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer’s standard accessory stands, stainless-steel mounting brackets, and attaching hardware.

1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
2. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
3. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders, and carrying case.

F. Tool Set: Shotgun hot stick with energized terminal indicator, and carrying case.

G. Ground Bails: Heavy duty grounding bails shall be provided to accommodate portable grounding equipment.

2.6 ARC-PROOFING MATERIALS

A. Tape for First Course on Metal Objects: Scotch 88, 10-mil- (250-micrometer-) thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.

B. Arc-Proofing Tape: Scotch 77, fireproof tape, flexible, conformable, and intumescent to 0.3 inch (8 mm) thick, compatible with cable jacket.

C. Self-fusing Silicon Tape: Scotch 70, high temperature, arc and track resistant tape composed of self-fusing, inorganic silicone rubber.

D. Glass-Cloth Tape: Scotch 69, Pressure-sensitive adhesive type, 1/2 inch (13 mm) wide.

2.7 SOURCE QUALITY CONTROL

A. Test and inspect cables according to ICEA S-97-682 before shipping.

B. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig (35 kPa).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Minimum cable size shall be #1/0 awg.
B. Cables for all circuits shall be 15 kV rated.

C. Install cables according to IEEE 576.

D. Pull Conductors: Do not exceed manufacturer’s recommended maximum pulling tensions and sidewall pressure values for single or multi-conductor cables.
   1. A strand dynamometer/tension meter shall be used during the cable installation, readings shall be recorded and a report submitted for each cable pull and witnessed by a representative of the NU Electric Shop.
   2. Where necessary, use manufacturer-approved pulling compound or lubricant that will not deteriorate conductor or insulation.
   3. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips that will not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
   4. Provide cable lengths with liberal allowances of slack for terminations.
   5. Cable shall not be pulled with the ends open, cable ends shall be moisture proofed at all times until terminations are installed.

E. Install underground cables in Sch. 40 PVC conduits in concrete encased ductbanks, comply with Section 26 0543.

F. In buildings and at road crossings, install cables in concrete encased Rigid Galvanized Conduit (Heavy-wall).

G. Provide a 1” PVC conduit centered in the top of the ductbank containing a green—jacketed #12 awg copper “tracer” wire.

H. Medium voltage cables shall not be direct buried.

I. Install permanent markers at ends of cable runs, changes in direction, and splices.

J. Install "buried-cable" warning tape above ductbanks. Comply with Division 26 Sections “Underground Ducts and Raceways” and “Identification for Electrical Systems”. Tape damaged during construction shall be completely replaced.

K. In manholes, hand holes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit and support cables with suitable UL listed non-metallic racks, located at intervals adequate to prevent sag.

L. Pull all cables in continuous lengths, splices in feeder circuits shall be avoided unless necessitated by the length of the run more than 500 feet. Locations of all splices shall be approved by the University’s Chief Electrician or his representative in writing.

M. Outdoor splices and terminations shall be performed in dry conditions only.

N. Three–Way splices are not permitted.

O. Install separable insulated-connector components as follows:
   1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
P. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, or termination materials such as transformers, switchgear, and manholes. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:

1. Clean cable sheath.
2. Wrap metallic cable components with 10-mil (250-micrometer) pipe-wrapping tape.
3. Smooth surface contours with electrical insulation putty.
4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
5. Band arc-proofing tape with 1-inch-(25-mm-) wide bands of half-lapped, adhesive, glass-cloth tape 2 inches (50 mm) O.C.

Q. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Sections and University Fire Protection Group.

1. All penetrations shall be under constant visual surveillance until firestopping is applied.

R. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.

S. Identify cables according to Division 26 Section 26 0553 "Identification for Electrical Systems."

1. Identify individual phases at termination points.
2. In manholes, cables shall be identified where cables enter and leave the manhole. Identify circuit number and voltage.
3. Use embossed brass tags tie wrapped to cable.

3.2 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
2. After installing medium-voltage cables and terminations but before electrical circuitry has been connected to busses or switchgear and energized, test for compliance with requirements, including but not limited to DC high potential testing according to IEEE 400 and insulation resistance testing.
3. Submit all reports to the NU Electric Shop prior to permanently energizing any cables.

B. Remove and replace non-compliant cable or terminations and retest as specified above.

END OF SECTION 26 0513
SECTION 26 0519 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Building wires and cables rated 600 V and less.
   2. Connectors, splices, and terminations rated 600 V and less.

B. Related Sections include the following:
   1. Division 27/28 Sections for cabling used for voice and data circuits.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by UL and marked for intended use.

B. Comply with ASTM.

C. Comply with UL 44, 83, and 486.

D. Comply with NFPA 70.

E. Comply with most current edition of the Northwestern University Design Standards.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Include data sheets for the following additional items:
   1. Splices and terminations.
   2. Pulling compounds.
   3. Cable accessories.

C. Field quality-control test reports.
1.5 PROJECT CONDITIONS (Delete If Not Required)

A. [Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by the University or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify the University Electric Shop no fewer than [two] calendar weeks in advance of proposed interruption of electric service.
2. Indicate method of providing temporary utilities.
3. Do not proceed with interruption of electrical service without the University’s Chief Electrician’s written permission.
4. University Lock-out/Tag-out procedures shall be used with Contractor controlled locks and tags.
5. Comply with NFPA 70E.]

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. General Cable Corporation.
2. Okonite Company.
4. Or equal approved in writing by the University’s Chief Electrician.

B. Copper Conductors: Comply with NEMA WC 70.

1. Aluminum conductors shall not be used under any circumstances.

C. Conductor Insulation: Comply with NEMA WC 70 for Types THHN, THWN, THWN-2, XHHW-2 and SO.

1. Voltage rating: 600 Volts for 480/277V and 208/120V.

D. VFD Cable:

1. Comply with UL 1277, UL 1685, and NFPA 70 for Type TC-ER cable.
2. Type TC-ER with oversized cross-linked polyethylene insulation, [spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire] [dual spirally wrapped copper tape shields and three bare symmetrically applied ground wires], and sunlight- and oil-resistant outer PVC jacket.
3. Comply with UL requirements for cables in [Class _, Division _ hazardous location] applications.

E. Multi-conductor Cable type MC and AC: Use of MC or AC cable is not permitted under any circumstances unless specifically approved in writing by the University’s Chief Electrician.

F. Use of Nonmetallic sheathed (NM) cable is not permitted under any circumstances.
2.2 CONNECTORS AND SPLICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Burndy, Thomas & Betts.
2. O-Z/Gedney; EGS Electrical Group LLC.
3. 3M; Electrical Products Division.
4. Ilsco.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

1. Aboveground Circuits (No. 10 AWG and smaller):
   a. Connectors: Solderless, screw-on, reusable pressure cable type, rated 600 V, 90˚ C, with integral insulation, approved for copper conductors.
   b. The integral insulator shall have a skirt to completely cover the stripped wires.
   c. The number, size, and combination of conductors, as listed on the manufacturer's packaging, shall be strictly followed.
   d. Use of “push-in” type splice connectors is not permitted.

2. Aboveground Circuits (No. 8 AWG and larger):
   a. Cable termination lugs shall be made of high conductivity and corrosion-resistant material, electro-tin plated, listed for use with copper conductors only, rated for 600 V. Lugs shall be color coded by size.
   b. Cable termination lugs shall be indent type, long barrel with chamfered entry, 2 – hole, compression type for 250 kcmil and above, 1 – hole for less than 250 kcmil.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Soft annealed Copper stranded, class B compressed.

B. Branch Circuits: Copper. Stranded for No. 12 AWG and larger.

C. Minimum Wire Size: #12 awg for power and lighting circuits, #14 awg for control circuits. In the case of “homeruns” over 125 feet in length, no conductor smaller than a No. 10 wire shall be used. The tap conductor from the J-box in the ceiling to the receptacle may be No. 12. Each 120-volt phase conductor shall have a neutral conductor of the same size. The sizing of all wire except remote control wire shall be accomplished in the case of both feeder and branch circuits by conforming to the following provisions. Only lighting circuits may share grounding conductors. All lighting circuits with shared grounding conductors shall be #10 AWG minimum.
3.2 CONDUCTOR INSULATION AND MULTI-CONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance:  Type XHHW, or type THHN/THWN up to and including 600 kcmil, single conductors in conduit.

B. Exposed Feeders:  Type THHN/THWN for all sizes up to and including 600 kcmil, single conductors in conduit.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type XHHW for #2 awg and larger, or type THHN/THWN for all sizes up to and including 600 kcmil, single conductors in conduit.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and underground: Type XHHW for #2 awg and larger, single conductors in conduit.

E. Exposed Branch Circuits, Including in Crawlspace: Type XHHW, single conductors in conduit.

F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type XHHW, single conductors in conduit.

G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and underground: Type XHHW single conductors in conduit.

H. VFD Output Circuits: Type TC-ER cable [with braided shield] [with dual tape shield].

I. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, and strain relief device at terminations to suit application. Service voltage shall not exceed 240 VAC.

J. Recessed or Semi-recessed Lighting Fixture Whips: Type THHN-THWN (90 deg C), single conductors in FMC in lengths not to exceed six (6) feet.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Splices in feeder circuits shall be avoided unless necessitated by the length of the run more than 500 feet. Locations of all splices shall be approved by the University’s Chief Electrician and made in Code sized splice box with the word “SPLICE” permanently labeled on cover.

B. Conductors may be run parallel from sizes 250 kcmil up to and including 600 kcmil provided all paralleled conductors are of the same size, manufacturer, length and type of insulation.

C. Homeruns may not contain more than three circuits.

D. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

E. Use pulling means; including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or conduit.

F. Identify and color-code conductors and cables according to Division 26 Section “Identification for Electrical Systems” for secondary service, feeders and branch circuits.
G. **(Delete for new buildings)** [Existing buildings: all unused or damaged cable/wire shall be removed; cable/wire may not be abandon in place.]

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet or junction box with at least 6 inches (150 mm) of slack.

3.5 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Sections and University Fire Protection Standards.

   1. All penetrations shall be under constant visual surveillance until firestopping is applied.
   2. Products: Cooper B-Line, 3m, Hilti, Specified Technologies, Inc.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

   1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors, and conductors feeding the following critical equipment and services for compliance with requirements.

   a. Generator, UPS, and Fire Pump.


C. Test Reports: Prepare a written report to record the following:

   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

D. Remove and replace non-compliant cables or wires and retest as specified above.

END OF SECTION 26 0519
PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
B. Northwestern University IT/IS Standards for electronic equipment, and voice/data systems grounding requirements.

1.2 SUMMARY
A. Section Includes: Grounding systems and equipment.
B. Section includes grounding systems and equipment, plus the following special applications:
   1. Underground distribution grounding.
   2. Ground bonding common with lightning protection system.

1.3 ACTION SUBMITTALS
A. Product Data: For each type of product indicated.

1.4 INFORMATIONAL SUBMITTALS
A. Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:
   1. Test wells.
   2. Ground rods.
   3. Ground rings.
   4. Grounding arrangements and connections for separately derived systems.
   5. Grounding for sensitive electronic equipment.
B. Field quality-control/test reports.

1.5 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Instructions for periodic testing and inspection of grounding features at test wells, ground rings, and grounding connections for separately derived systems based on NFPA 70B.
a. Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.

b. Include recommended testing program and intervals.

c. Include test results and updated single line diagrams.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

C. Comply with NFPA 70.

D. Comply with FM Global requirements.

E. Comply with City of [Chicago] [Evanston] Electrical Code.

F. Comply with most current edition of the Northwestern University Design Standards.

PART 2 - PRODUCTS (Edit Per Job Requirements)

2.1 CONDUCTORS

A. Insulated Conductors: Tinned-copper wire or cable insulated for 600 V with green colored insulation, UL 44 or UL 83 listed, unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches (6.3 by 100 mm) in cross section, provided with standard NEMA bolt hole sizing and spacing for the type of connectors to be used. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V, Lexan or PVC, impulse tested at 5000 V. Provide clear Lexan cover over connections.
2.2 CONNECTORS

A. Listed and labeled by an UL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure type with at least two bolts.
   1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

D. Bus-bar Connectors: Mechanical type, cast silicon bronze, solder-less compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet (19 mm by 3 m) in diameter.

PART 3 - EXECUTION *(Edit Per Job Requirements)*

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.
   1. Bury at least 24 inches (600 mm) below grade.
   2. Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank as part of duct-bank installation. Bury detectable warning tape approximately 6 inches (150 mm) above grounding conductors. Warning tape shall comply with Section 26 0553.

C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

D. Grounding Bus: Install in electrical rooms, in rooms housing service equipment, and elsewhere as indicated.
   1. Install bus on insulated spacers 2 inches (50 mm) minimum from wall, 12 inches (300 mm) above finished floor unless otherwise indicated.

E. Conductor Terminations and Connections:
   1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Exothermic welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.

### 3.2 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

**A.** Comply with IEEE C2 grounding requirements.

**B.** Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches (100 mm) will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches (50 mm) above to 6 inches (150 mm) below concrete. Seal floor opening with waterproof, non-shrink grout.

**C.** Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

**D.** Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2/0 for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 12 inches (300 mm) from the foundation.

### 3.3 UTILITY GROUNDING

**A.** Provide grounding and bonding at Utility Company’s metering equipment in accordance with Utility Company’s requirements.

### 3.4 EQUIPMENT GROUNDING

**A.** Install insulated equipment grounding conductors with all feeders and branch circuits.

1. Conduit shall not be used as the ground conductor.
2. Where required by Code, metallic conduit may be used as an additional means of grounding where the raceway system qualifies as a grounding conductor in accordance with NEC 250.118.

**B.** Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Armored cable runs.

C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to first section of air duct and connected metallic piping.

D. Water Heater, Heat-Tracing, and Anti-frost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

E. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

F. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

G. Cable trays shall be grounded and bonded in accordance with N.E.C. requirements and Northwestern University IT/IS Standards.

H. Raised floors: Provide bonding of all raised floor components.

I. Signal, Data, and Communication Equipment: Comply with requirements in Northwestern University IT/IS Standards.

J. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

K. Outdoor metallic fences around electrical equipment shall be grounded and bonded to equipment grounding loops, coordinate with “Fencing” Specification Sections and installing Contractor.

3.5 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

1. Where ground conductors are subject to physical damage, install in raceway.

B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground
directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Ground Rods: Drive rods until tops are 12 inches (100 mm) below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.

D. Test Wells: Ground rod driven through bottom of handhole. Handholes are specified in Division 26 Section "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches (300 mm) deep, with cover.

1. Test Wells: Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor. Cover shall be labeled "GROUND".

2. Provide test well in service vaults.

E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.

2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

F. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.

3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.

I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of building.
1. Install tinned-copper conductor not less than No. 4/0 AWG for ground ring and for taps to building steel.
2. Bury ground ring not less than 24 inches (600 mm) from building's foundation.

J. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70; use a minimum of 20 feet (6 m) of bare copper conductor not smaller than No. 4 AWG.
   1. If concrete foundation is less than 20 feet (6 m) long, coil excess conductor within base of foundation.
   2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.
   3. UFER ground electrode shall be properly supported to insure proper placement while concrete is being poured, the conductor shall be supported every 30'' or less and be properly tensioned to prevent sag.

3.6 LABELING
   A. Comply with requirements in Division 26 Section "Identification for Electrical Systems" Article for instruction signs. The label shall be green and its text shall be black.

3.7 FIELD QUALITY CONTROL
   A. Perform tests and inspections.
      1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

   B. Tests and Inspections:
      1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
      2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
      3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.
         a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
         b. Perform tests by fall-of-potential method according to IEEE 81.
      4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
C. Grounding system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports, submit to the University’s Chief Electrician or his designated representative.

E. Report measured ground resistances that exceed the following values:
   
   1. Power and Lighting Equipment or System with Capacity of 500 kVA and less: 10 ohms.
   2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
   3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
   4. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).

F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.

G. For existing systems which have been modified, update maintenance records and single lines and turn over to Electric Shop.

END OF SECTION 26 0526
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.
B. IMC: Intermediate metal conduit.
C. RMC: Rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS

A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.5 ACTION SUBMITTALS

A. Product Data: For the following:

1. Steel slotted support systems.
2. Nonmetallic slotted support systems.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
1. Trapeze hangers. Include Product Data for components.
2. Steel slotted channel systems. Include Product Data for components.
3. Nonmetallic slotted channel systems. Include Product Data for components.
4. Equipment supports.

1.6 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.7 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. All products shall be UL labeled for their intended use.

C. Comply with NFPA 70.

D. Comply with most current edition of the Northwestern University Design Standards.

1.8 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Sections.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Sections.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Cooper B-Line, Inc.; a division of Cooper Industries.
      b. Thomas & Betts Corporation.
      c. Unistrut; Tyco International, Ltd.

   2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
   3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
   4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
   5. Channel Dimensions: Selected for applicable load criteria.
B. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch-(14-mm)-diameter holes at a maximum of 8 inches (200 mm) o.c., in at least 1 surface.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Allied Tube & Conduit.
      b. Cooper B-Line, Inc.; a division of Cooper Industries.

C. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

D. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

F. Structural Steel for fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

G. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
   1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened Portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Hilti Inc.
         2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
         3) MKT Fastening, LLC.
         4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.

   2. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened Portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Cooper B-Line, Inc.; a division of Cooper Industries.
         2) Empire Tool and Manufacturing Co., Inc.
         3) Hilti Inc.
         4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
         5) MKT Fastening, LLC.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 05 Sections for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with single-bolt conduit clamps or single-bolt conduit clamps using spring friction action for retention in support channel.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

E. Fire pump feeders that are run exposed shall have conduit supported every five feet from a two hour rated structure with UL listed components.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.
C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
6. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 05 Sections for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit and four inches high, and so anchors will be a minimum of 10 bolt diameters from edge of the base. Edges shall be chamfered.

B. Use 3000-psi (20.7-MPa) 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Concrete Sections.

C. Install dowel rods to connect concrete bases to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.

D. Anchor equipment to concrete base.
1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touchup: Comply with requirements in Division 09 Painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A-780.

END OF SECTION 26 0529
SECTION 26 0533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Northwestern IT/IS Standards for raceways and cable trays for Telecommunications cabling.

1.2 SUMMARY

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Nonmetallic conduits, tubing, and fittings.
3. Metal wireways and auxiliary gutters.
4. Surface raceways.
5. Poke Thru Assemblies.

B. Related Requirements:

1. Division 26 Section "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.

1.3 DEFINITIONS

A. GRC: Galvanized rigid steel conduit.

B. IMC: Intermediate metal conduit.

C. EMT: Electrical Metallic Tubing.

D. PVC: Polyvinyl Chloride

1.4 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. (Delete If Not Required) [LEED Submittals:]
1. **Product Data for Credit IEQ 4.1:** For solvent cements and adhesive primers, documentation including printed statement of VOC content.

C. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

D. **Samples:** For wireways, nonmetallic wireways and surface raceways and for each color and texture specified, 12 inches (300 mm) long.

1.5 QUALITY ASSURANCE

A. All products shall be UL labeled for their intended use.

B. Comply with NFPA 70.

C. Comply with City of [Chicago] [Evanston] Electrical Code.

D. Comply with most current edition of the Northwestern University Design Standards.

1.6 INFORMATIONAL SUBMITTALS

A. Source quality-control reports.

B. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

   1. Structural members in paths of conduit groups with common supports.
   2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

1.7 Special Warranty for PVC coated GRC and fittings: Manufacturers standard form in which manufacturer of the conduit and fittings agrees to replace components that fail in materials or workmanship within specified warranty period.

A. Five years after beneficial occupancy by University.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, products of all manufacturers are acceptable provided they have a smooth interior, are UL listed and labeled as defined in NFPA 70 for the intended location and application and are electro-galvanized steel (EMT) or hot dipped galvanized steel inside and out (GRC). For PVC coated GRC, conduit and fittings shall be obtained from the same manufacturer:

B. GRC: Comply with ANSI C80.1 and UL 6.

C. PVC coated GRC: Comply with ANSI C80.1, UL 6 and NEMA RN – 1.
D. IMC: Comply with ANSI C80.6 and UL 1242.
E. EMT: Comply with ANSI C80.3 and UL 797.
F. FMC: Comply with UL 1; zinc-coated steel.
G. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
H. Multi-conductor Cable type MC and AC: Use of MC or AC cable is not permitted under any circumstances unless specifically approved in writing by the University’s Chief Electrician.
I. Electrical nonmetallic tubing (ENT or “blue tube”) and liquid-tight flexible nonmetallic conduit (LFNC) are not acceptable for use on any Project.
J. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
   1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
   2. Fittings for GRC:
      a. Material: Steel.
      b. Type: threaded.
   3. Fittings for PVC coated GRC:
      a. Urethane coating of nominal 2 mil thickness shall be uniformly and consistently applied to the interior of all fittings.
      b. All female threads on fittings and couplings shall be protected by urethane coating.
   4. Fittings for EMT:
      a. Material: Steel.
      b. Type: compression – indoors; compression - outdoors.
      c. Set screw fittings are prohibited.
   5. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
   6. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.

K. Joint Compound for IMC or GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS
A. Manufacturers: Subject to compliance with requirements, products of all manufacturers are acceptable provided they are sunlight resistant and UL listed and labeled as defined in NFPA 70 and marked for intended location and application. Conduit and fittings shall be obtained from the same manufacturer.
B. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
C. Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

D. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper B-Line, Inc.
2. Hoffman; a Pentair company.
3. Square D; a brand of Schneider Electric.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.

1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Screw-cover type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.4 SURFACE RACEWAYS

A. Listing and Labeling: Surface raceways shall be UL listed and labeled as defined in NFPA 70 and marked for intended location and application.

B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finishes in color selected by Architect. Provide dividers as required to separate systems of different voltages.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Panduit Corp.
   b. Wiremold / Legrand #700 or better.

2.5 POKE THRU ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Hubbell Incorporated; Wiring Device-Kellems.
2. Pass & Seymour/Legrand; Wiring Devices & Accessories.
3. Thomas & Betts Corporation.
4. Wiremold Company (The).
B. Poke-Thru Assemblies:

1. Factory-fabricated and - wired assembly of below-floor junction box with multi-channeled, through-floor raceway/firestop unit and detachable matching floor service outlet assembly.
2. Steel service head and junction box.
3. Poke-thru box fittings shall maintain a minimum two-hour fire rating.
4. Comply with UL 514 scrub water exclusion requirements.
5. Service Outlet Assembly: Flush type with services indicated.
6. Selected to fit nominal 4-inch (100-mm) cored holes in floor and matched to floor thickness.

2.6 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper Crouse-Hinds.
2. EGS/Appleton Electric.
3. FSR Inc.
4. Hoffman; a Pentair company.
5. Hubbell Incorporated; Killark Division.
7. RACO; a Hubbell Company.
8. Thomas & Betts Corporation.
9. Wiremold / Legrand.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

1. Minimum depth shall be 2-1/8 inches.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

E. Metal Floor Boxes:

1. Material: Sheet metal, 11 gauge.
2. Type: Flush. Cover with 0.25”square aluminum flange rated for carpet/tile installations. Provide pour pan accessory for on-grade installations.
3. Shape: Rectangular.
4. Listing and Labeling: Metal floor boxes shall be listed and labeled UL 514A.

F. Luminaire Outlet Boxes: Brass or Steel, Nonadjustable, designed for attachment of luminaire weighing 50 lb (23 kg). Outlet boxes designed for attachment of luminaires weighing more than 50 lb (23 kg) shall be listed and marked for the maximum allowable weight.

G. Sheet Metal Pull and Junction Boxes 100 cu. in. and smaller: NEMA OS 1.

H. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.
I. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

J. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.
   1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
   3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

K. Cabinets:
   1. NEMA 250, Type 1 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
   2. Hinged door in front cover with flush latch and concealed hinge.
   3. Key latch to match panelboards: Corbin #4T3142. Confirm with NU Electric Shop.
   4. Metal barriers to separate wiring of different systems and voltage.
   5. Accessory feet where required for freestanding equipment.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
   1. Exposed Conduit: GRC, IMC, or RNC, Type EPC-80-PVC.
   2. Concealed Conduit, Aboveground: IMC, EMT, or RNC, Type EPC-40-PVC.
   3. Underground Conduit: RNC, Type EPC-40-PVC, direct buried or concrete encased as indicated.
   4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
   5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:
   1. Exposed, Not Subject to Physical Damage: EMT.
   2. Exposed, Not Subject to Severe Physical Damage (Mechanical rooms and similar): IMC.
   3. Exposed and Subject to Severe Physical Damage (Parking Garages or where indicated): GRC.
   4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
   5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
   6. Feeders over 600 V: GRC.
   7. Damp or Wet Locations: GRC or IMC.
   8. Pools, Corrosive and Similar Locations: PVC coated GRC.
   9. Basements, mechanical and electrical rooms: IMC
   10. Tunnels: GRC.
   11. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.
   12. In concrete slabs: Type EPC-40-PVC.
   13. PVC conduit shall not be run in wall spaces or building cavities.
C. Minimum Raceway Size: 3/4-inch trade size for branch circuits, one-inch embedded in slabs, and five-inch for primary services. Maximum fill for branch circuit conduits: 30%

D. Mixing different types of conduits indiscriminately in the same system is prohibited.

E. Raceway Fittings: Compatible with raceways and suitable for use and location.
   1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
   2. EMT: Use watertight compression type steel fittings with insulated throat. Comply with NEMA FB 2.10.
   3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

F. Install surface raceways only where indicated on Drawings.

G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F (49 deg C).

3.2 INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

B. Installers of the PVC-coated galvanized rigid conduit system shall be certified by the manufacturer and be able to present a valid, unexpired certified installer card prior to starting installation. All manufacturer’s clamping, cutting, threading, bending, and assembly instructions shall be followed

C. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

D. Where two or more conduits are run together they shall be racked. Use minimum ¼”x20 threaded rod to support “trapeze” type racks.

E. Installation of all new conduits must be minimum 12 inches from ceiling grid except where approved by the Chief Electrician.

F. Complete raceway installation before starting conductor installation.

G. Comply with requirements in Northwestern University Design Standards for hangers and supports.

H. Arrange stub-ups so curved portions of bends are not visible above finished slab.

I. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches (300 mm) of changes in direction.

J. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

K. Support conduit within 12 inches (300 mm) of enclosures to which attached.
L. All suspension systems must be hung independently from structure; “piggyback” suspension systems for raceways are prohibited.

M. PVC Raceways Below Slabs:
   1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot (3-m) intervals.
   2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
   3. Arrange raceways to keep a minimum of 3 inches (75 mm) of concrete encasement in all directions.
   4. Do not embed threadless fittings in concrete unless specifically approved by the Chief Electrician for each specific location. Fittings shall be concrete tight.

N. PVC Large Diameter Raceways Bending Radius:
   1. Four-inch conduit: 35" minimum.
   2. Five-inch: 50" minimum.

O. Stub-ups to Above Recessed Ceilings:
   1. Use EMT for raceways.
   2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

P. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

Q. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

R. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch (35mm) trade size and insulated throat metal bushings on 1-1/2-inch (41-mm) trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

S. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

T. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

U. Cut conduit perpendicular to the length. For conduits 2-inch (53-mm) trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

V. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

W. Surface Raceways:
1. Install surface raceway with a minimum 2-inch (50-mm) radius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

X. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

Y. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Where otherwise required by NFPA 70.

Z. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

AA. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C) and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F (55 deg C) and that has straight-run length that exceeds 100 feet (30 m).
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
   a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
   b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
   c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
   d. Attics: 135 deg F (75 deg C) temperature change.
3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F (0.0115 mm per meter of length of straight run per deg C) of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
BB. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches (1830 mm) of flexible conduit for recessed and semi-recessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations.
2. Use a maximum of 72 inches (1830 mm) of ½” FMC for recessed and semi-recessed luminaires. Use of 3/8” FMC is permitted subject to review by the Chief Electrician.
3. Final connections to motors or equipment subject to vibration, noise transmission, or movement shall use FMC not exceeding four feet in length.
4. Short lengths of FMC shall be used for final primary and secondary connections to Low Voltage transformers (<600V).

CC. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

DD. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between boxes and cover plate or supported equipment and box.

EE. Do not install boxes back-to-back in walls. Provide minimum 6-inch separation in non-fire-rated walls. Provide minimum 24-inch horizontal separation in acoustic-rated walls.

FF. Boxes shall be secured between two studs. Boxes connected to one stud are not permitted.

GG. Locate boxes so that cover or plate will not span different building finishes.

HH. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

II. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

JJ. Set metal floor boxes level and flush with finished floor surface.

3.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies.

3.4 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Sections and Northwestern Fire Protection Standards.


3.5 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."
B. Junction boxes of different systems shall be identified by colors indicated below. Box and cover shall be painted prior to attaching identification labels.

C. Provide permanent nameplates for all pull and junction boxes identifying circuits, voltage, and source.

D. Where conduit is exposed in public or finished areas, the conduits shall be painted to match the adjacent wall or ceiling color. Associated junction boxes and covers shall be painted inside to match Northwestern standard conduit color code below.

E. Raceways and couplers of different systems shall be identified by color. Raceways up to 4” shall have **factory applied finish**.

   1. Raceways up to 4” shall have solid color within electrical rooms and vaults.
   2. Raceways larger than 4” shall be identified by permanent snap-on color bands installed within six inches of any pull or junction box, enclosure, fitting, and every twenty feet of run.

F. Colors: 

   System:

   1. Red  Fire Alarm.
   2. Yellow Feeders: 600V and above.
   3. Orange Feeders: 277V and < 600V.
   4. White Feeders: 120V to 240V.
   5. Blue Building Automation.
   6. Green Grounding and “Hogan” systems
   7. Yellow w/Red stripe Gas monitoring

3.6 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

   1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
   2. Repair damage to paint finishes with matching touchup coating recommended by manufacturer.
   3. Repair damage to PVC coatings with matching touchup coating recommended by manufacturer.

END OF SECTION 26 0533
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SECTION 26 0543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Northwestern IT/IS Standards for Telecommunications pathway requirements.

1.2 SUMMARY

A. This Section includes the following:

1. Conduit, ducts, and duct accessories for direct-buried and concrete-encased duct banks, and in single duct runs.
2. Handholes and boxes.

1.3 DEFINITION

A. RNC: Rigid nonmetallic conduit.

B. RGC: Rigid galvanized conduit.

1.4 ACTION SUBMITTALS

A. Product Data: For the following:

1. Duct-bank materials, including separators and miscellaneous components.
2. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Accessories for manholes, handholes, boxes, and other utility structures.
4. Warning tape.

B. Shop Drawings for Precast or Factory-Fabricated Underground Utility Structures: Shop drawings shall be sealed by a Professional Engineer. Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:

1. Duct entry provisions, including locations and duct sizes.
2. Reinforcement details.
3. Frame and cover design and manhole frame support rings.
4. Ladder details.
5. Grounding details.
6. Dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
7. Joint details.
C. Shop Drawings for Factory-Fabricated Handholes and Boxes Other Than Precast Concrete: Include dimensioned plans, sections, and elevations, and fabrication and installation details, including the following:
   1. Duct entry provisions, including locations and duct sizes.
   2. Cover design.
   4. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.5 INFORMATIONAL SUBMITTALS
A. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.
   1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
B. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C 858.
C. Qualification Data: For professional engineer.
D. Source quality-control test reports.
E. Field quality-control test reports.

1.6 QUALITY ASSURANCE
A. All products shall be UL labeled for their intended use.
B. Comply with the current edition of Northwestern Design Standards, including IT/IS Standards for Low Voltage systems pathways.
C. Comply with ANSI C2.
D. Comply with NFPA 70.

1.7 DELIVERY, STORAGE, AND HANDLING
A. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.
B. Lift and support precast concrete units only at designated lifting or supporting points.

1.8 PROJECT CONDITIONS *(Delete If Not Required)*
A. [Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by the University or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:}
1. Notify the University’s Chief Electrician no fewer than [two] calendar weeks in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without the University’s Chief Electrician’s written permission.
3. Northwestern Lock-out/Tag-out procedures shall be used with Contractor controlled locks and tags.
4. Comply with NFPA 70E.

1.9 COORDINATION

A. Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.

B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by the Northwestern Project Manager.

PART 2 - PRODUCTS

2.1 CONDUIT


B. RNC: NEMA TC 2, Type EPC-40-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.2 NONMETALLIC DUCTS AND DUCT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, products of all manufacturers are acceptable provided they are sunlight resistant and UL listed for the intended installation. Conduit and fittings shall be provided from the same manufacturer whenever possible.

B. Duct Accessories:
   1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling.
   2. Warning Tape: Underground-line warning tape specified in Division 26 Section 26 0553 "Identification for Electrical Systems."

2.3 HANDHOLES AND BOXES

A. Description: Comply with SCTE 77.
   1. Tier 22 rated.
   2. Color: Gray.
   3. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.

5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

6. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.


8. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have factory-installed inserts for cable racks and pulling-in irons.

B. Polymer Concrete Handholes and Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Highline Products
   c. NU Electric Shop approved equal.

2. Cover Legend: Cast in, selected to suit system.
   a. Legend: "NU-ELECTRIC" for duct systems with power wires and cables for systems operating at 600 V and less.
   b. Legend: "NU-ELECTRIC" for duct systems with medium-voltage cables.
   c. Legend: "NU-SIGNAL" for communications, data, and telephone duct systems.

2.4 PRECAST MANHOLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Elmhurst Chicago Stone Company.
2. Cretex.
3. Utility Concrete Products.

B. Comply with ASTM C 858, with structural design loading as specified in Part 3 "Underground Enclosure Application" Article and with interlocking mating sections, complete with accessories, hardware, and features.

1. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.
   a. Windows shall be located no less than 6 inches (150 mm) from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
   b. Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
   c. Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.
C. Concrete Knockout Panels: 1-1/2 to 2 inches (38 to 50 mm) thick, for future conduit entrance and sleeve for ground rod.

D. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

2.5 UTILITY STRUCTURE ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. East Jordan Iron Works, Inc.
2. McKinley Iron Works, Inc.

B. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.

1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 30B with milled cover-to-frame bearing surfaces; diameter, 29 inches (737 mm).
   a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
   b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.
   c. Covers shall have locking provisions.

2. Cover Legend: Cast in. Selected to suit system.
   a. Legend: "NU-ELECTRIC" for duct systems with power wires and cables for systems operating at 600 V and less.
   b. Legend: "NU-ELECTRIC" for duct systems with medium-voltage cables.
   c. Legend: "NU-SIGNAL" for communications, data, and telephone duct systems.

3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.
   a. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. (60 L) where packaged mix complying with ASTM C 387, Type M, may be used.

C. Manhole Sump Frame and Grate: ASTM A 48/A 48M, Class 30B, gray cast iron.

D. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch- (50-mm-) diameter eye, and 1-by-4-inch (25-by-100-mm) bolt.

1. Working Load Embedded in 6-Inch (150-mm), 4000-psi (27.6-MPa) Concrete: 13,000-lbf (58-kN) minimum tension.
2. Four required.

E. Pulling-In and Lifting Irons in Concrete Floors: 7/8-inch- (22-mm-) diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.
1. Ultimate Yield Strength: 40,000-lbf (180-kN) shear and 60,000-lbf (270-kN) tension.
2. Four required.

F. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch (13-mm) ID by 2-3/4 inches (69 mm) deep, flared to 1-1/4 inches (32 mm) minimum at base.
1. Tested Ultimate Pullout Strength: 12,000 lbf (53 kN) minimum.

G. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.
1. Stanchions: Nominal 36 inches (900 mm) high by 4 inches (100 mm) wide, with minimum of 9 holes for arm attachment.
2. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3 inches (75 mm) with 450-lb (204-kg) minimum capacity to 20 inches (508 mm) with 250-lb (114-kg) minimum capacity. Top of arm shall be nominally 4 inches (100 mm) wide, and arm shall have slots along full length for cable ties.

H. Duct-Sealing Compound: Non-hardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F (2 deg C). Capable of withstanding temperature of 300 deg F (150 deg C) without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

I. Fixed Manhole Ladders: Arranged for attachment to roof or wall and floor of manhole. Ladder and mounting brackets and braces shall be fabricated from non-conductive fiber reinforced resin.

J. Cover Hooks: Heavy duty, designed for lifts 60 lbf (270 N). Two required.

2.6 SEAL – SLEEVE ASSEMBLIES

A. Products: “Link-Seal”® by GPT Industries.

B. Exterior Wall or Stub-Ups through Floor: Modular seal assembly to provide a hydrostatic seal, using mechanical interlocking synthetic rubber links shaped to fill the annular opening between the conduit and the wall. Pressure plate shall be reinforced nylon-polymer. Hardware shall be stainless steel.

C. Sleeves shall be Schedule 40 galvanized steel pipe.

2.7 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C 1037.

B. Non-concrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
PART 3 - EXECUTION

3.1 UNDERGROUND DUCT APPLICATION

A. Minimum conduit/duct size for underground installations shall be one inch for branch circuits, four inch for primary and main feeder conductors, and four inch for telecom services.

B. Ducts for Electrical Cables over 600 V: (select) [Evanston: RNC, NEMA Type EPC-40 PVC]; [Chicago: RGC], in concrete-encased duct bank, unless otherwise indicated.

C. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-40 PVC, in concrete-encased duct bank, unless otherwise indicated.

D. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-40 PVC, in direct-buried duct bank, unless otherwise indicated.

E. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-40 PVC, in direct-buried duct bank, unless otherwise indicated.

F. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EPC-40 PVC, in concrete-encased duct bank, unless otherwise indicated.


H. A nylon pull cord shall be installed and tied off in each duct, including spares. The nylon pull cord shall have a minimum tensile strength of 200 pounds.

3.2 UNDERGROUND ENCLOSURE APPLICATION

A. Handholes and Boxes for 600 V and Less, Including Telephone, Communications, and Data Wiring:

1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete, AASHTO HB 17, H-20 structural load rating.
2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Non-deliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20; Polymer concrete, SCTE 77, Tier 15 structural load rating.
3. Units in Sidewalk and Similar Applications with a Safety Factor for Non-deliberate Loading by Vehicles: Precast concrete, AASHTO HB 17, H-10, Polymer concrete units, SCTE 77, Tier 8 structural load rating.

B. Manholes: Precast concrete.
1. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.
2. Units Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.

3.3 EARTHWORK

A. Excavation and Backfill: Comply with earth moving sections in Division 31 Specifications, but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary top-soiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with plantings Section in Division 32 Specifications.

D. Cut and patch existing pavement in the path of underground ducts and utility structures according to appropriate Division 01 Sections.

3.4 DUCT INSTALLATION

A. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes to drain in both directions.

1. This Contractor shall be fully responsible for corrective action necessary to insure water infiltration is eliminated.

B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep GRC bends with a minimum radius of \[ \text{(Select)} \quad 48 \text{ inches (1220 mm)} \quad [12.5 \text{ feet (4 m)}] \quad [25 \text{ feet (7.5 m)}], both horizontally and vertically, at other locations, unless otherwise indicated.

1. \[ \text{Large diameter PVC bend radius: 4” duct – 35”; 5” duct – 50”; 6” duct – 61”} \]

C. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.

D. Duct Entrances to Manholes and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches (250 mm) O.C. for 5-inch (125-mm) ducts, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to end-bell spacing 10 feet (3 m) from the end bell without reducing duct line slope and without forming a trap in the line.

2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to manhole or handhole.

3. Grout end bells into structure walls from both sides to provide watertight entrances.

E. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 10 feet (3 m) outside the building wall without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit
transition. Install conduit penetrations of building walls using galvanized steel sleeves. At floor and exterior wall conduit penetrations, completely seal the gap around conduit to render it watertight using “Link-Seal ®” products modular seal assemblies.

F. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.

G. Connections to Existing Ducts: Where connections to existing ducts are indicated, excavate around the ducts as necessary. Cut off the ducts and remove loose concrete from inside before installing new ducts. Provide a reinforced-concrete collar, poured monolithically with the new ducts, to take the shear at the joint of the duct banks.

H. Concrete-Encased Ducts: Support ducts on duct separators.

1. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 feet (6 m) of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches (150 mm) between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.

2. Concrete: 3000 psi (20 kPa), 28-day strength, complying with Division 03 Concrete Sections. RED DYE shall be added to the concrete mix and shall be consistent throughout.

3. Concreting Sequence: Place each run of concrete envelope between manholes or other terminations in one continuous operation.
   a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the concrete placement. Use expansion fittings installed according to manufacturer's written recommendations, or use other specific measures to prevent expansion-contraction damage.
   b. If more than one concrete placement is necessary, terminate each in a vertical plane and install 3/4-inch (19-mm) reinforcing rod dowels extending 18 inches (450 mm) into concrete on both sides of joint near corners of envelope.

4. Placing Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.

5. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth, road crossings and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.

6. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be placed without soil inclusions; otherwise, use forms.

7. Minimum Space between Ducts: 3 inches (75 mm) between ducts and exterior envelope wall, 2 inches (50 mm) between ducts for like services, and 12 inches (300 mm) between power and signal ducts.

8. Depth: Depth: Install top of duct bank at 36 inches (900 mm) below finished grade, unless otherwise indicated.

9. Stub-Ups: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor for all circuit conductors.
a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
b. Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of base. Install insulated grounding bushings on terminations at equipment.
c. Stub-Ups shall be half-lap wrapped with PVC tape, and shall extend a minimum of 1.5 M (5 feet) away from the edge of slab.

10. Install insulated grounding bushings on conduit terminations.
11. Warning Tape: Comply with Section 260553. Bury warning tape approximately 18 inches (450 mm) above all concrete-encased ducts and duct banks. Align tape parallel to and within 3 inches (75 mm) of the centerline of duct bank. Provide an additional warning tape for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional tapes 12 inches (300 mm) apart, horizontally.
12. Provide a 1” PVC conduit centered in the top of the ductbank containing a green-jacketed #12 awg copper “tracer” wire.

I. Direct-Buried Duct Banks:

1. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
2. Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 feet (6 m) of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches (150 mm) between tiers.
3. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in earth moving sections in Division 31 Specifications for pipes less than 6 inches (150 mm) in nominal diameter.
4. Install backfill as specified in earth moving sections in Division 31 Specifications.
5. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand-place backfill to 4 inches (100 mm) over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction as specified in earth moving sections in Division 31 Specifications.
6. Install ducts with a minimum of 3 inches (75 mm) between ducts for like services and 12 inches (300 mm) between power and signal ducts.
7. Depth: Install top of duct bank at 36 inches (900 mm) below finished grade, unless otherwise indicated.
8. Set elevation of bottom of duct bank below the frost line.
9. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
10. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
11. Warning Tapes: Comply with Section 260553. Bury warning tape approximately 18 inches (450 mm) above all duct banks. Align tape parallel to and within 3 inches (75 mm) of the centerline of duct bank. Provide an additional warning tape for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional tapes 12 inches (300 mm) apart, horizontally.

12. Provide a 1" PVC conduit centered in the top of the ductbank containing a green–jacketed #12 awg copper “tracer” wire.

3.5 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

A. Precast Concrete Handhole and Manhole Installation:

1. Comply with ASTM C 891, unless otherwise indicated.
2. Install unit level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.
3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch (25-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

B. Elevations:

1. Manhole Roof: Install with rooftop at least 18 inches (450 mm) below finished grade.
2. Manhole Frame: In paved areas and traffic-ways, set frames flush with finished grade. Set other manhole frames 1 inch (25 mm) above finished grade.
3. Install handholes with bottom below the frost line, <Insert depth of frost line below grade at Project site> below grade.
4. Handhole Covers: In paved areas and traffic-ways, set surface flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.
5. Where indicated, cast handhole cover frame integrally with handhole structure.

C. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

D. Manhole Access: Circular opening in manhole roof; sized to match cover size.

1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
2. Install chimney, constructed of precast concrete collars and rings to support frame and cover and to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for cast-iron frame to chimney.

E. Waterproofing: Apply waterproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Waterproofing materials and installation are specified in Division 07 Sections. After ducts have been connected and grouted, and before backfilling, waterproof joints and connections and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days. Joint between manhole and chimney shall be sealed with a flexible epoxy or EPDM rubber seal.

F. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms as required for installation and support of cables and conductors and as indicated.

G. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.
H. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches (98 mm) for manholes and 2 inches (50 mm) for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

I. Warning Sign: Install “Confined Space Hazard” warning sign on the inside surface of each manhole cover.

3.6 INSTALLATION OF HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.7-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and traffic-ways, set so cover surface will be flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.

D. Install handholes and boxes with bottom below the frost line, <Insert depth of frost line below grade at Project site> below grade.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.

F. Field-cut openings for ducts and conduits according to enclosure manufacturer’s written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

G. For enclosures installed in asphalt paving and concrete and subject to occasional, non-deliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.
   1. Concrete: 3000 psi (20 kPa), 28-day strength, complying with Division 03 Concrete Sections with a troweled finish.
   2. Dimensions: 10 inches wide by 12 inches deep (250 mm wide by 300 mm deep).

3.7 GROUNDING

A. Ground underground ducts and utility structures according to Division 26 Section “Grounding and Bonding for Electrical Systems.”

3.8 IDENTIFICATION

A. Comply with Division 26 Section “Identification for Electrical Systems.”
3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
3. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.10 CLEANING

A. Pull mandrel duct cleaner sized at least 75% of the conduit diameter, through the full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of manholes, including sump. Remove foreign material.

END OF SECTION 26 0543
PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
A. Section Includes:
   1. Identification for raceways.
   2. Identification of power and control cables.
   3. Identification for conductors.
   5. Warning labels and signs.
   6. Instruction signs.
   7. Equipment identification labels.
   8. Miscellaneous identification products.

1.3 ACTION SUBMITTALS
A. Product Data: For each electrical identification product indicated.

1.4 QUALITY ASSURANCE
A. Comply with ANSI A13.1.
B. Comply with NFPA 70.
C. Comply with NFPA 70E.
E. Comply with ANSI Z535.4 for safety signs and labels.
F. (Select based on project location) [Comply with City of Chicago Codes and Standards.] [Comply with City of Evanston Codes and Standards.]
G. Comply with most current edition of the Northwestern University Design Standards.
H. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
PART 2 - PRODUCTS

2.1 POWER RACEWAY IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.

B. Colors for Raceways Carrying Circuits at more than 600 V:
   1. Black letters on a yellow field.
   2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch-(75-mm-) high letters.

C. Colors for Raceways Carrying Circuits at 277 V up to 600V: and conduits larger than two inches:
   1. Black letters on an orange field.
   2. Legend: Indicate voltage and system or service type.

D. Colors for Raceways Carrying Circuits at 120 V up to 240V: and conduits larger than two inches:
   1. Black letters on a white field.
   2. Legend: Indicate voltage and system or service type.

E. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

F. Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less and conduits larger than two inches: Slit, pre-tensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

G. Colors for Raceways Carrying Circuits at 600 V or Less and conduits two inches and less:
   1. Comply with Section 26 0533.

2.2 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

2.3 CONDUCTOR IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tapes not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.
B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

C. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

D. Write-On Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
   1. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.4 FLOOR MARKING TAPE
A. 2-inch- (50-mm-) wide, 5-mil (0.125-mm) pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

2.5 UNDERGROUND-LINE WARNING TAPE
A. Tape:
   1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
   2. Printing on tape shall be permanent and shall not be damaged by burial operations.
   3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils, consisting of a printed pigmented polyolefin film, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
   4. Overall Thickness: 5 mils (0.125 mm).
   5. Foil Core Thickness: 0.35 mils (0.00889 mm).
   6. Weight: 28 lb/1000 sq. ft. (13.7 kg/100 sq. m).
   7. 3-Inch (75-mm) Tensile According to ASTM D 882: 70 lbf (311.3 N), and 4600 psi (31.7 MPa).

B. Color and Printing:
   1. Comply with ANSI Z535.1 through ANSI Z535.5.
   2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
   3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

2.6 WARNING LABELS AND SIGNS

B. Baked-Enamel Warning Signs:
   1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
   2. 1/4-inch (6.4-mm) grommets in corners for mounting.
   3. Nominal size, 7 by 10 inches (180 by 250 mm).
C. Metal-Backed, Butyrate Warning Signs:

1. Weather-resistant, non-fading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal size, 10 by 14 inches (250 by 360 mm).

D. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 48 INCHES (1220 MM)."
3. Arc Flash Protection Field Marking: All panelboards, switchgear, switchboards, panelboards motor control centers, motor control panels and electrical control panels shall be provided with a black on yellow warning sign per ANSI Z535.4 and ISO 3864. The sign shall read: “WARNING! ARC FLASH and SHOCK HAZARD. APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT REQUIRED.” The sign shall be prominently mounted on the front of the equipment, readily visible and indicate all relevant class information. If the equipment has multiple removable front covers, a sign shall be mounted on each cover. For flush mounted panelboards in finished spaces, the sign shall be mounted on the inside of the door or inside cover. Manufacturers’ standard labels are not acceptable.

2.7 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. inches (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes.

1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

B. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.

2.8 EQUIPMENT IDENTIFICATION NAMEPLATES

A. Engraved, Laminated Acrylic or Melamine Nameplate: Minimum letter height shall be ½ inch (13 mm). Refer to Drawings for Nameplate Detail.

B. Fasteners for nameplates: stainless steel screws that do not change the NEMA or NRTL rating of the enclosure, adhesive labels shall not be used.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).
B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

B. Apply identification devices to surfaces that require finish after completing finish work.

C. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

D. Attach signs and plastic labels with mechanical fasteners appropriate to the location and substrate.

E. System Identification Color-Coding Bands for Raceways Larger than Two Inches: Each color-coding band shall completely encircle conduit. Locate bands at changes in direction, at penetrations of walls and floors, at 30-foot maximum intervals in straight runs, in electrical rooms and vaults color shall be solid, see “Raceways” Section.

F. System Identification Labels for Raceways carrying circuits above 600V: Locate labels at changes in direction, at penetrations of walls and floors, at 30-foot maximum intervals in straight runs, at 10-foot maximum intervals in electrical rooms and vaults, and within six inches of pull or junction boxes.

G. System Identification Labels for Raceways carrying circuits 600V and less: Locate labels at changes in direction, at penetrations of walls and floors, at 30-foot maximum intervals in straight runs.

H. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 18 inches overall. Comply with Section 26 0543.

I. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

3.2 IDENTIFICATION SCHEDULE

A. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend, system voltage, and panel/circuit number. System legends shall comply with Section 26 0533 – 3.5.D.

1. Normal power.
2. Emergency power.
3. UPS.
B. Power-Circuit Conductor Identification, 600 V or Less: For conductors in electric rooms or vaults pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder, and branch-circuit conductors.
   a. Color shall be factory applied.
   b. Colors for 208/120-V Circuits:
      1) Phase A: Black.
      2) Phase B: Red.
      3) Phase C: Blue.
      4) Neutral: White.
      5) Ground: Green.
   c. Colors for 480/277-V Circuits:
      1) Phase A: Brown.
      2) Phase B: Orange.
      3) Phase C: Yellow.
      4) Neutral: Gray.
      5) Ground: Green with Yellow Stripe.
   d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
   e. Switch loops shall retain correct color code with a white tracer.
   f. For new work in existing buildings, the existing identification method shall be used for new conductors provided it meets all requirements of this Section and the NEC.

C. Install instructional sign including the color code for grounded and ungrounded conductors using adhesive-film-type labels.

D. Emergency Sources: A sign shall be placed at the service entrance equipment indicating the type and location of on-site emergency power sources per NEC Art. 700.

E. Elevator Disconnects: Provide “Fed From” signs indicating the location of the supply side OCPD for each elevator power source.

F. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.

   1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
   2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
H. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.

1. Install underground-line warning tape for both direct-buried cables and cables in raceway.

I. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

J. Arc Flash warning labels shall be provided on all new electrical equipment and existing equipment that has been modified a part of a project and conform to Arc Flash report.

K. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs or Metal-backed, butyrate warning signs.

2. Identify system voltage.
3. Apply to exterior of door, cover, or other access.
4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:
   a. Power transfer switches.
   b. Controls with external control power connections.
   c. Other equipment as indicated on the Drawings.

L. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

M. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer and load shedding.

N. Provide permanent nameplates for all pull and junction boxes identifying circuits, voltage, and source.

O. Wiring device identification: comply with Section 26 2726 – 3.2.B.

P. Equipment Identification Nameplates: On each unit of equipment, install unique designation nameplate that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply nameplates to Switchgears, Switchboards, Distribution Panels, Panelboards, Transformers, Individual Starters, Contactors, Disconnect Switches, Transfer Switches, Control Panels and Similar Equipment. Systems include power, lighting, and control systems unless equipment is provided with its own identification.

1. Colors for equipment nameplates:
   a. NORMAL power system:
      1) 120V – 240V: black letters on white background.
      2) 277V – 600V: black letters on orange background.
      3) 600V and up: black letters on yellow background.
b. Emergency (EM) & Essential (ES) 480/277V loads as defined by NEC Art. 700 – Red letters w/black outline on Orange background. Differentiate EM from ES (Chicago) and EM, LR, OS, and CS (Evanston).

c. LIFE SAFETY loads as defined by NEC Art. 700: white letters on red background.

d. Emergency (EM) & Essential (ES) 208/120V as defined by NEC Art. 700 – Red letters on white background. Differentiate EM from ES (Chicago) and EM, LR, OS, and CS (Evanston).

e. LEGALLY REQUIRED loads as defined by NEC Art. 701 (elevators, smoke control, HVAC, etc.): TBD.

f. OPTIONAL STANDBY loads as defined by NEC Art. 702 (Labs, HVAC, etc.): Red letters on white background.

2. Labeling Instructions:

   a. Identify the piece of equipment, the source, voltage characteristics, and the load served.

   b. Indoor Equipment: Engraved, laminated acrylic or melamine nameplate. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.

   c. Outdoor Equipment: Engraved, laminated acrylic or melamine nameplate. Unless otherwise indicated, provide a single line of text with one-inch- (26-mm-) high letters on 3-inch- (76-mm-) high label; where two lines of text are required, use labels 4 inches (100 mm) high.

   d. Elevated Components: Increase sizes of nameplates and letters to those appropriate for viewing from the floor.

   e. Fasten nameplates with appropriate stainless steel screws that do not change the NEMA or NRTL rating of the enclosure. Stick-on or adhesives are not acceptable unless the NEMA enclosure rating is compromised, then only epoxy adhesive shall be used to attach nameplates.

END OF SECTION 26 0553
SECTION 26 0800 - COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. The purpose of this section is to specify the Division 26 responsibilities and participation in the commissioning process.

B. Work under this contract shall conform to requirements of Division 01, General Requirements, Conditions of the Contract, and Supplementary Conditions. This specification covers commissioning of electrical systems which are part of this project.

C. Commissioning work shall be a team effort to ensure that all electrical equipment and systems have been completely and properly installed, function together correctly to meet the design intent, and document system performance. Commissioning shall coordinate system documentation, equipment start-up, and verification and performance testing.

D. The commissioning team shall be made up of representatives from the University, design professionals, major equipment suppliers, and construction trades. The trades represented on the commissioning team shall include, but not be limited to, sheet metal, piping and fitting, controls, test and balance, and electrical. The lead person for each trade who will actually perform or supervise the work is to be designated as the representative to the commissioning team. Responsibility for various steps of the commissioning process shall be divided among the members of the commissioning team, as described in this section.

E. The Commissioning Authority shall have responsibility for coordinating and directing each step of the commissioning process. The Authority shall be a true third party, not affiliated with any of the companies involved with the project design.

F. Electrical system installation, start-up, testing, preparation of O&M manuals, and operator training are the responsibility of the Division 26 Contractors, with coordination, observation, verification and commissioning the responsibility of Division 01, Section 01 9113. The 01 9113 commissioning process does not relieve Division 26 from the obligations to complete all portions of work in a satisfactory and fully operational manner.

G. Refer to Division 01, Section 01 9113, for a full list of commissioning related definitions. A few critical definitions are included below:

1. Commissioning. A systematic process that provides documented confirmation that specific and interconnected fire and life safety systems function according to the intended design criteria set forth in the project documents and satisfy the University’s operational needs, including compliance requirements of any applicable laws, regulations, codes, and standards requiring fire and life safety systems.

2. Commissioning Authority (CxA). The qualified person, company, or agency that plans, coordinates, and oversees the entire Cx process.

3. Commissioning Plan. The document prepared for each project, which identifies the processes and procedures necessary for a successful Cx process.
4. **Commissioning Record.** The complete set of commissioning documentation for the project, which is turned over to the University at the end of the construction phase.

5. **Functional Testing.** Tests performed to verify compliance with manufacturers’ specifications, applicable codes and standards, and the project BOD and OPR.

### 1.2 RELATED SECTIONS

A. Division 01 Section 01 9113 - General Commissioning Requirements

B. Division 21 Section 21 0800 - Commissioning of Fire Suppression

C. Division 22 Section 22 0800 - Commissioning of Plumbing Systems

D. Division 23 Section 23 0800 - Commissioning of HVAC Systems

E. Division 25 Section 25 0800 - Commissioning of Integrated Automation

F. Individual Division 01, 21, 22, 23, 25, and 26 sections contain requirements related to the commissioning process.

### 1.3 ROLES AND RESPONSIBILITIES

A. Refer to Section 01 9113 for Commissioning Authority, University, Architect, and General Contractor roles and responsibilities.

B. Refer to Section 21 0800 for fire protection contractor roles and responsibilities.

C. Refer to Section 22 0800 for plumbing contractor roles and responsibilities.

D. Refer to Section 23 0800 for HVAC contractor roles and responsibilities.

E. Refer to Section 25 0800 for integrated automation contractor roles and responsibilities.

F. Electrical Contractor
   1. Include cost to complete commissioning requirements for electrical systems in the contract price.
   2. Include requirements for submittal data, O&M data, and training in each purchase order or sub contract written.
   3. Ensure cooperation and participation of specialty sub-contractors such as communications, data, etc.
   4. Ensure participation of major equipment manufacturers in appropriate training and testing activities.
   5. Attend Construction Phase coordination meeting scheduled by the Commissioning Authority.
   6. Conduct electrical system orientation and inspection when equipment is set.
   7. Respond to (in writing) and address items documented in the Contractor Commissioning Issues Log.
   8. Submit copies of all test results to the CxA.
9. Complete Pre-Functional Checklists for all equipment.
   a. If no other system is agreed upon by Commissioning Team, Mechanical Contractor shall be responsible for completion of Pre-Functional Checklists for all equipment for which it issued a purchase order.
   b. Mechanical Contractor shall coordinate completion of Pre-Functional Checklists with all other contractors that have made connections to equipment for which it issued a purchase order.
   c. Remedy any deficiencies identified in Pre-Functional Checklists and notify CxA in writing that deficiencies have been addressed.

10. Assist the Commissioning Authority in all Pre-Functional Checklist verifications and Functional Performance Tests.

11. Prepare preliminary schedule for electrical system orientation and inspections, O&M manual submission, training sessions, emergency generator testing, equipment start up, and task completion for use by the Commissioning Authority. Update schedule as appropriate throughout the construction period.

12. Attend initial training session.

13. Conduct electrical system orientation and inspection at the equipment placement completion stage.

14. Update drawings to the record condition to date, and review with the Commissioning Authority.

15. Gather O&M data on all equipment, and assemble in binders as required by the Commissioning Specification. Submit to Commissioning Authority for review prior to the completion of construction.

16. Notify the Commissioning Authority a minimum of two weeks in advance, so that witnessing equipment and system start-up and testing can begin.

17. Participate in, and schedule vendors and Contractors to participate in the training sessions as set up by the Commissioning Authority.

18. Provide a complete set of as-built records to the Commissioning Authority.

G. Equipment Suppliers and Miscellaneous Contractors

   1. Include cost for commissioning requirements in the contract price.
   2. Provide submittals, and appropriate O&M manual section(s).
   3. Attend initial commissioning coordination meeting scheduled by the Commissioning Authority.
   4. Participate in training sessions as scheduled by the Commissioning Authority.
   5. Demonstrate performance of equipment as applicable.

1.4 SCOPE OF WORK

A. Commissioning work of Division 26 shall include, but not be limited to:

   1. Testing and start-up of the equipment.
   2. Completion of Functional Checklists.
   3. Cooperation with the Commissioning Authority.
   4. Providing qualified personnel for participation in commissioning tests, including seasonal testing required after the initial testing.
   5. Providing equipment, materials, and labor as necessary to correct construction and/or equipment deficiencies found during the commissioning process.
   6. Providing operation and maintenance manuals, and as-built drawings to the Commissioning Authority for verification.
   7. Providing training and demonstrations for the systems specified in this Division.
B. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems, and sub-systems. The following equipment and systems shall be evaluated:

1. Indoor lighting and controls including power transfer schemes, emergency lighting, and outdoor lighting.
2. Emergency power monitoring and operation
3. Electrical support for mechanical equipment listed in Section 23 0800 - Commissioning of HVAC Systems

C. System components which will not be functionally performance tested but will be included in the commissioning scope for conformance to the design documents, verification of specified Contractor testing, construction phase observation, and training verification shall include:

1. Primary switchgear
2. Primary transformer
3. Main switchgear
4. Distribution switchgear
5. Distribution Switchboards
6. Panel boards
7. Isolation power systems
8. Power conditioners
9. Power factor correction
10. Paralleling gear
11. Automatic transfer switch
12. Lighting protection
13. Grounding system
14. SCADA system
15. Lighting and lighting controls

D. Timely and accurate documentation is essential for the commissioning process to be effective. Documentation required as part of the commissioning process shall include but not be limited to:

1. Commissioning Process Reports, which may include the following:
   a. Commissioning Field Reports
   b. Design Team Issues Log
   c. Contractor Commissioning Issues Log on the WCxS
   d. Meeting minutes
2. Pre-start, and start-up procedures
3. Pre-functional Checklists
4. Functional Test Procedures
5. Training agenda and materials
6. As-built records
7. Commissioning report
8. Operation and maintenance (O&M) manuals
9. Mapping of reports into maintenance programs

E. Detailed testing shall be performed on all installed equipment and systems to ensure that operation and performance conform to contract documents. All tests shall be witnessed by the Commissioning Authority. The following testing is required as part of the commissioning process:
1. Functional Checklists are comprised of a full range of checks and tests to determine that all components, equipment, systems, and interfaces between systems operate in accordance with contract documents. Verification is completed by the Division 23, 26, and 28 contractors and documented using Functional Checklists.

2. Functional Performance Tests (FPT) shall determine if the electrical system is operating in accordance with the design intent. This includes all operating modes, interlocks, control responses, and specific responses to abnormal or emergency conditions.

F. Comprehensive training of O&M personnel shall be performed by the Electrical Contractor, and where appropriate, by other sub-contractors, and vendors prior to turnover of building to the University. The training shall include classroom instruction, along with hands-on instruction on the installed equipment and systems.

1.5 DOCUMENTATION

A. The Commissioning Authority shall oversee and maintain the development of the document process. The GC shall facilitate project documentation through the web-based commissioning software. The commissioning documentation shall include, but not be limited to, the following:

1. Commissioning Plan
2. Commissioning Schedule
3. Document Request Log
4. Commissioning RFIs
5. Commissioning Field Reports
6. Design Team Issues Log on the WCxS
7. Contractor Commissioning Issues Log on the WCxS
8. Pre-Functional Checklists
9. Functional Performance Tests

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. The appropriate Contractor(s) shall furnish all special tools and equipment required for testing during the commissioning process. A list of all tools and equipment to be used during commissioning shall be submitted to the Commissioning Authority for approval. The University shall furnish necessary utilities for the commissioning process.

2.2 TEST EQUIPMENT – PROPRIETARY

A. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the University upon completion of the commissioning process.
PART 3 - EXECUTION

3.1 GENERAL

A. A pre-construction meeting of all commissioning team members shall be held at a time and place designated by the University. The purpose shall be to familiarize all parties with the commissioning process, and to ensure that the responsibilities of each party are clearly understood.

B. The Contractor shall complete all phases of work so the systems can be started, tested, balanced, and commissioning procedures undertaken. This includes the complete installation of all equipment, materials, pipe, duct, wire, insulation, controls, etc., per the contract documents and related directives, clarifications, and change orders.

C. A Commissioning Plan shall be developed by the Commissioning Authority. The Contractor shall assist the Commissioning Authority in preparing the Commissioning Plan by providing all necessary information pertaining to the actual equipment and installation. If contractor initiated system changes have been made that alter the commissioning process, the Commissioning Authority shall notify the University.

D. Acceptance procedures are normally intended to begin prior to completion of a system and/or sub-systems, and shall be coordinated with the Division 26 contractor. Start of acceptance procedures before system completion does not relieve the contractor from completing those systems as per the schedule.

3.2 PARTICIPATION IN COMMISSIONING

A. The Contractor shall provide skilled technicians to start-up and debug all systems within Division 26. These same technicians shall be made available to assist the Commissioning Authority in completing the commissioning program. Work schedules, time required for testing, etc., shall be requested by the Commissioning Authority and coordinated by the contractor. Contractor shall ensure that the qualified technician(s) are available and present during the agreed upon schedules and of sufficient duration to complete the necessary tests, adjustments, and/or problem resolutions.

B. System performance problems and discrepancies may require additional technician time, Commissioning Authority time, reconstruction of systems, and/or replacement of system components. The additional technician time shall be made available for subsequent commissioning periods until the required system performance is obtained.

C. The Commissioning Authority reserves the right to question the appropriateness and qualifications of the technicians relative to each item of equipment, system, and/or sub-system. Qualifications of technicians shall include expert knowledge relative to the specific equipment involved and a willingness to work with the Commissioning Authority. Contractor shall provide adequate documentation and tools to start-up and test the equipment, system, and/or sub-system.

3.3 DEFICIENCY RESOLUTION

A. In some systems, maladjustments, misapplied equipment, and/or deficient performance under varying loads will result in additional work being required to commission the systems. This work shall be completed under the direction of the University, with input from the contractor,
equipment supplier, and Commissioning Authority. Whereas all members shall have input and the opportunity to discuss, debate, and work out problems, the University shall have final jurisdiction over any additional work done to achieve performance.

B. Corrective work shall be completed in a timely fashion to permit the completion of the commissioning process. Experimentation to demonstrate system performance may be permitted. If the Commissioning Authority deems the experimentation work to be ineffective or untimely as it relates to the commissioning process, the Commissioning Authority shall notify the University, indicating the nature of the problem, expected steps to be taken, and suggested deadline(s) for completion of activities. If the deadline(s) pass without resolution of the problem, the University reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner shall be the contractor’s responsibility.

C. The University’s contract with the Commissioning Authority includes up to two tests of each piece of equipment or system included in the commissioning scope. Commissioning Authority time and expenses required for retests beyond two, if required, due to incomplete installation or otherwise, will be paid by the University and reimbursed by the contractor.

3.4 ADDITIONAL COMMISSIONING

A. Additional commissioning activities may be required after system adjustments, replacements, etc., are completed. The contractor(s), suppliers, and Commissioning Authority shall include a reasonable reserve to complete this work as part of their contractual obligations.

3.5 SEASONAL COMMISSIONING

A. Seasonal commissioning pertains to testing under full load conditions during peak heating and peak cooling seasons, as well as part load conditions in the spring and fall. Initial commissioning shall be done as soon as contract work is completed, regardless of season. Subsequent commissioning may be undertaken at any time thereafter to ascertain adequate performance during the different seasons.

B. Heating equipment shall be tested during winter design extremes. Cooling equipment shall be tested during summer design extremes with a fully occupied building. Each contractor and supplier shall be responsible to participate in the initial and the alternate peak season tests of the systems as required to demonstrate performance.

3.6 CONSTRUCTION PHASE OBSERVATION

A. Scope of Construction Phase Observation

1. The Commissioning Authority will conduct periodic observations during the construction phase to monitor progress and compliance with the design intent and contract documents.
2. Commissioning Authority observations will coincide with design team observations and are not intended to take the place of this work.

B. Documentation and Reporting
1. Issues identified by the Commissioning Authority during construction phase will be documented on the Issues Log on the WCxS and distributed to Commissioning Team members.

2. Progress during the construction phase will also be documented by the Commissioning Authority using Commissioning Process Reports.

3.7 ACCEPTANCE PROCEDURES

A. Pre-Functional Checklists

1. Scope of Pre-Functional Checklists
   a. Tests and verifications included in the Pre-Functional Checklists shall determine if all components, equipment, systems, and interfaces between systems are installed and are ready to operate in accordance with contract documents.

2. Participants in Pre-Functional Checklists
   The Commissioning Authority shall be responsible for preparing the scope of these checklists, which will be completed by the installing contractors and then verified (via spot checking and Functional Performance Testing). Participating contractors, manufacturers, suppliers, etc. shall include all costs to do the work involved in these tests in their proposals. Following is a list of tasks and supporting information that shall be required:

   a. HVAC Contractor - provide the services of a technician(s) who is (are) familiar with the construction and operation of this system. Provide access to the contract plans, shop drawings, and equipment cut sheets of all installed equipment.

   b. Controls Contractor - provide the services of a controls engineer who is familiar with the details of the project. Provide details of the control system, schematics, and a narrative description of control sequences of operation.

   c. Electrical Contractor - provide a foreman electrician familiar with the electrical interlocks, interfaces with emergency power supply, and interfaces with alarm and life-safety systems. Provide access to the contract plans, and all as-built schematics of sub-systems, interfaces, and interlocks.

3. Documentation and Reporting Requirements

   a. Pre-Functional Checklists shall be provided for each component, piece of equipment, system, and sub-system, including all interfaces, interlocks, etc. Each item to be tested shall have a different entry line with space provided for comments. The checklists will include spaces for each party to sign off on.

   b. Completed checklists shall be submitted to the Commissioning Authority for acceptance and inclusion in the commissioning report.

4. Acceptance of Pre-Functional Checklists

   a. The Commissioning Authority will select, at random, 10% of the checklists for verification, 100% of the Fire Alarm checklist.

   b. If 10% or more of the checklists are found to be inaccurate for each system or equipment type, all of the checklists for that system or equipment type will be rejected. Complete, accurate checklists will need to be resubmitted.
B. Functional Performance Testing

1. Scope of Functional Performance Testing
   a. Functional performance tests shall determine if the electrical system is operating in accordance with the final design intent. This includes all operating modes, interlocks, control responses, and specific responses to abnormal or emergency conditions.

2. Submittals
   a. Detailed procedures for each series of tests will be developed by the Commissioning Authority for review and acceptance by the University. The procedures shall include samples of the data sheets that will be part of the reports.

3. Participants in Functional Performance Tests
   a. Participants in the functional performance tests shall be the same as those listed in the Functional Checklists.

4. Functional Performance Test Procedures
   a. The Commissioning Authority shall supervise and direct all functional performance tests.

      1) Set the system equipment into the operating mode to be tested (i.e. normal shut-down, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
      2) The Commissioning Authority shall inspect and verify the position of each device and interlock identified in the test procedure. Each item shall be signed off as acceptable (yes) or failed (no).
      3) This test shall be repeated for each operating cycle that applies to the mechanical system being tested.
      4) Operating checks shall include all safety cutouts, alarms, and interlocks with smoke control and life safety systems during all modes of operation of the electrical system.
      5) If during a test an operating an operating deficiency is observed, appropriate comments will be added to the web based commissioning software.

   b. If deficiencies are identified during Functional Performance Testing, the Construction Manager/General Contractor will be notified, and action taken to remedy the deficiency. The final completed functional test procedures on the WCxS will be reviewed by the Commissioning Authority to determine if testing is complete and the system is functioning in accordance with the contract documents.

5. Documentation and Reporting Requirements
   a. All measured data, data sheets, and a comprehensive summary, describing the operation of the electrical system at the time of testing shall be submitted to the Commissioning Authority.
   b. A preliminary functional performance test report shall be prepared by the Commissioning Authority and submitted to the Design Professional for review. Any identified deficiencies need to be evaluated by the Design Professional and
Construction Manager/General Contractor to determine if they are part of the contractor’s or sub-contractor’s contractual obligations. Construction deficiencies shall be corrected by the responsible contractor(s), and the specific functional performance test repeated.

C. If it is determined that the electrical system is constructed in accordance with the contract documents, and the performance deficiencies are not part of the contract documents, the University must decide whether any required modifications needed to bring the performance of the electrical system up to the finalized design intent shall be implemented, or if the test shall be accepted as submitted. If corrective work is performed, the University shall determine if a portion or all required functional performance tests should be repeated, and a revised report submitted.

3.8 SYSTEMS MANUAL:

A. The Systems Manual shall be submitted in paper AND/OR electronic format and shall contain the following major sections:

1. System Descriptions:
   a. Each major system shall be described, typewritten, in general terms, including major components, interconnections, theory of operation, theory of controls, unusual features and major safety precautions. This information should correlate with information provided in the manufacturers’ instructions book. This section shall include, but not be limited to, the following data:

      1) Detailed description of each system and each of its components with diagrams and illustrations where applicable.
      2) Wiring and control diagrams with data to explain detailed operation and control of each component
      3) Control sequences describing start-up, all modes of operation, and shut down
      4) Corrected shop drawings
      5) Approved product data including all performance curves and rating data
      6) Copies of approved certifications and laboratory or factory test reports (where applicable)
      7) Copies of warranties

   b. System diagrams, described in the following section, shall be incorporated in the appropriate systems descriptions. These should be reduced in size or folded to usefully fit into the manual.

2. Operating Instructions:
   a. Condensed, typewritten, suitable for posting, instructions shall be provided for each major piece of equipment. Where more than one (1) common unit is installed, one instruction is adequate. The instructions shall provide procedures for:

      1) Starting up the equipment/system
      2) Shutting down the equipment/system
      3) Operating the equipment in emergency or unusual conditions
      4) Safety precautions
      5) Trouble shooting suggestions
6) Other pertinent data applicable to the operation of particular systems or equipment
   
b. The instructions shall be suitable for posting adjacent to the equipment concerned.
c. The contractor shall provide instructions for (at minimum):
   1) Transformers
   2) Primary switchgear and substations
   3) Secondary Switchgear and Switchboards
   4) Automatic transfer switches
   5) Emergency power systems
   6) Electrical distribution systems
   7) Lighting control systems
   8) Fire alarm systems
   9) Security systems
   10) Clock systems
   11) Paging systems
   12) Uninterruptible power systems/Inverters
   13) SCADA system

3. Ongoing and Preventive Maintenance:
   a. Condensed, typewritten procedures for recommended ongoing and preventive maintenance actions shall be provided for each category of equipment/system listed above. This information shall include, but not be limited to the following:
      1) Maintenance and overhaul instructions.
      2) Parts list, including source of supply and recommended spare parts.
      3) Name, address, and 24 hour telephone number of each subcontractor who installed equipment and systems, and local representative for each type of system.
      4) Other pertinent data applicable to the maintenance of particular systems or equipment.
   b. These recommended preventive maintenance actions shall be categorized by the following recommended frequencies:
      1) Weekly
      2) Monthly
      3) Quarterly
      4) Semi Annual
      5) Annual
      6) Other

B. Posted Operating Instructions and Diagrams:
   1. Operating Instructions:
      a. Copies of operating instructions provided in the operating manual shall be posted in the near vicinity of each piece of applicable equipment. The instructions shall be mounted neatly in frames under Plexiglas, where they can be easily read by operating personnel. Instructions mounted outdoors shall be suitably protected from weather.
2. Posted Systems Diagrams:

   a. Simplified one-line diagrams of the systems listed shall be developed using AutoCAD and posted neatly under Plexiglas in the main or most appropriate equipment room for easy reference by operating and maintenance personnel. These drawings shall be done in a professional manner which is acceptable to the University. The diagrams shall show each component including all devices installed in the system, with name and identifying number. Explanatory notes, where needed, shall be provided.

      1) Electrical one-line diagrams
      2) Other systems as applicable
      3) Emergency lighting
      4) Generators and Transfer Switches
      5) Grounding System

   b. These diagrams shall be suitable for reduction in size and use in the operating manual system descriptions previously covered.

3.9 OPERATING AND MAINTENANCE TRAINING:

A. The Electrical Contractor, and appropriate sub-contractors, shall provide comprehensive operating and maintenance instruction on building systems prior to delivery. The instruction shall include classroom instruction delivered by competent instructors based upon the contents of the operating manual. Emphasis shall be placed upon overall systems diagrams and descriptions, and why systems were designed as they were. The classroom instruction shall also include detailed equipment instruction by qualified manufacturer representatives for which operating instructions are provided. The manufacturer representative training shall emphasize operating instructions, and preventive maintenance as described in the operating manual. At a minimum, the training sessions shall cover the following items:

1. Types of installed systems
2. Theory of operation
   a. Design intent
   b. Occupied vs. unoccupied or partial occupancy
   c. Seasonal modes of operation
   d. Emergency conditions, transfer schemes, and procedures
   e. Other issues important to facility operation
3. System operations
4. Service, maintenance, diagnostics and repair
5. Use of reports and logs
6. Troubleshooting, investigation of malfunctions, and determining reasons for the problem

B. Each classroom training period shall be followed by an inspection, explanation and demonstration of the system concerned by the instructors. All equipment listed in 3.07 A shall be started up and shut down, with the exception of sprinkler systems.

C. The contractor shall be responsible for organizing, arranging, and delivering this instruction in an efficient and effective manner on a schedule agreeable to the University.
D. The contractor shall provide, at or before substantial completion, a proposed agenda and schedule of the above training for approval by the Commissioning Authority and the University.
SECTION 26 1200 - MEDIUM-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following types of transformers with medium-voltage primaries:
   1. Liquid-filled distribution and power transformers (indoor).
   2. Dry type distribution and power transformers (indoor).

B. Related Sections include the following:
   1. Division 26 Section "Low Voltage Switchgear" for requirements for transformers that form a part of a unit substation.

1.3 DEFINITIONS


1.4 ACTION SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, location of each field connection, and performance for each type and size of transformer indicated.

B. Material Safety Data Sheet (MSDS) for insulating fluid in liquid filled units.

C. Shop Drawings: Diagram power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Underground primary and secondary conduit stub-up location.
   2. Dimensioned concrete base, outline of transformer, and required clearances.
   3. Ground rod and grounding cable locations.
B. Source quality-control test reports.
C. Field quality-control test reports.
D. Follow-up service reports.

1.6 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For transformer and accessories to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE
A. Product Options: Drawings indicate size, profiles, and dimensional requirements of transformers and are based on the specific system indicated.
B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
C. Comply with IEEE C2.
D. Comply with DOE 2016 (dry type up to 35 kV primary and 2500 kVA).
G. Oil or dry type: IEEE C57.12.70 and IEEE C57.12.80.
H. Comply with NFPA 70.
I. Comply with FM Global requirements for liquid filled transformers.
J. Comply with most current edition of the Northwestern University Design Standards.

1.8 DELIVERY, STORAGE, AND HANDLING
A. Store transformers protected from weather and so condensation will not form on or in units. Provide temporary heating according to manufacturer's written instructions.

1.9 PROJECT CONDITIONS
A. (Delete This Paragraph If Not Required) Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by The University or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
1. Notify the University no fewer than [two] calendar weeks in advance of proposed interruption of electric service.
2. Indicate method of providing temporary utilities.
3. Do not proceed with interruption of electrical service without the University’s Chief Electrician’s written permission.
4. The University Lock-out/Tag-out procedures shall be used with Contractor controlled locks and tags.
5. Comply with NFPA 70E.

B. Installation Pathway: Remove and replace building components and structures to provide pathway for moving transformers into place.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for transformers, including clearances between transformers and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Service Conditions: IEEE C37.121, usual service conditions except for the following: (Edit For Project Conditions)

1. Exposure to significant solar radiation.
2. Exposure to fumes, vapors, or dust.
3. Exposure to hot and humid climate or to excessive moisture, including steam, salt spray, and dripping water.
4. Exposure to abnormal vibration, shock, or tilting.
5. Exposure to excessively high or low temperatures.
6. Unusual transportation or storage conditions.
7. Unusual grounding-resistance conditions.
8. Unusual space limitations.

1.10 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of louvers, doors, spill retention areas, and sumps. Coordinate installation so no piping or conduits are installed in space allocated for medium-voltage transformers except those directly associated with transformers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB.
2. Cooper Industries; Cooper Power Systems Division.
4. GE Electrical Distribution & Control.
5. Square D; Schneider Electric.
Select Paragraph 2.2, 2.3, or 2.4 below per Project Requirements

2.2 LIQUID-FILLED DISTRIBUTION AND POWER TRANSFORMERS

A. Description: IEEE C57.12.00 and UL 1062, liquid-filled, 2-winding transformers installed indoors, typically as part of a unit substation assembly.

B. Primary terminations shall be designed for close coupling to a metal enclosed air load break switch section. Secondary terminations shall be designed for close coupling to [a switchgear section] [a switchboard section].

C. Insulating Liquid: Less flammable, silicone-based dielectric and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be FM approved and have low toxicity and be nonhazardous.

D. Insulation Temperature Rise: 65/55 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C. Insulation system shall be rated to continuously allow an additional 12 percent kilovolt-ampere output, at 65 deg C temperature rise, without decreasing rated transformer life.

E. High-voltage and low-voltage windings shall be copper. Insulation between layers of the windings shall be by thermally set insulating paper or equal.

F. Optional [Surge Arresters: Distribution class, one for each primary phase; complying with IEEE C62.11 and NEMA LA 1; within high-voltage compartment.]

G. Basic Impulse Level: 95 for 15 kV.

H. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, 2 above and 2 below rated primary voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.

I. Cooling System: Class OA/FA, self-cooled, and with forced-air-cooled rating. Cooling systems shall include auxiliary cooling equipment (fans), automatic controls, and status indicating lights necessary to obtain an additional 15% capacity on units 300 through 2000 kVA and an additional 25% capacity on units 2500 kVA and over. A separate control power source shall be provided for fans and controls.

J. Sound level may not exceed sound levels listed in NEMA TR 1, without fans operating.

K. Impedance: +/- 7-1/2%.

L. Accessories: Lifting lugs and provisions for jacking under base. Transformers shall have a steel base and frame allowing use of pipe rollers in any direction, and an insulated, low-voltage, neutral bushing with removable ground strap. Include the following additional accessories:

1. Liquid-level gage.
2. Pressure-vacuum gage.
3. Liquid temperature indicator.
4. Drain and filter valves.
5. Pressure relief device.
6. Additional nameplate with FM approval data.
7. Alarm contacts for gages and thermometer listed above.
8. SCADA interface.
9. Two stainless steel ground pads.

2.3 DRY TYPE DISTRIBUTION AND POWER TRANSFORMERS

A. Description: NEMA and ANSI C57 compliant and UL 1062, 2-winding transformers installed indoors, typically as part of a unit substation assembly. UL listed.

B. Primary terminations shall be designed for close coupling to **[a metal enclosed air load break switch section]** [an air terminal chamber provided with the transformer]. Secondary terminations shall be designed for close coupling to **[a switchgear section]** [a switchboard section].

C. Cores shall be manufactured from non-aging, cold rolled, high permeability grain oriented silicone steel.

D. High and Low Voltage windings shall be Copper.

E. Insulating System: Coils shall be insulated with **220° C Class H Nomex® insulation system.** Environmental protection shall be provided by vacuum pressure impregnation with polyester resin (VPI).

F. Insulation Temperature Rise: 115° C, based on an average ambient temperature of 30° C over 24 hours with a maximum ambient temperature of 40° C. Insulation system shall be rated to allow the transformer to be overloaded to the 150° C temperature rise, without decreasing rated transformer life.

G. Optional **[Surge Arresters: Distribution class, one for each primary phase; complying with IEEE C62.11 and NEMA LA 1; within high-voltage compartment.]**

H. Basic Impulse Level: **[60 for 5 kV] [95 for 15 kV].**

I. Full-Capacity Voltage Taps: Four nominal 2.5% taps, 2 above and 2 below rated primary voltage; accessible by removing the enclosure panels.

J. Cooling System: Class OA/FA, self-cooled, and with forced-air-cooled rating. Fan cooling package shall be provided for automatically increasing the kVA rating by 33% and include auxiliary cooling equipment (fans), automatic controls to digitally monitor winding temperature and ambient temperature. Form C contacts shall be provided to trip the transformer off-line for excessive winding temperature. LED status indicating lights. A 4-20 mA analog signal shall be provided for remote indication or for use with SCADA systems. Power shall be provided from an internal fused control power transformer.

K. Heavy gauge, sheet steel NEMA 1 enclosure, ventilated, with removable panels for access to taps. The complete case shall be capable of being knocked down to reduce size and weight for rigging. Rubber vibration isolation pads shall be installed by the manufacturer between the core and coil and the enclosure. Finish: manufacturer’s standard ANSI 61 paint finish.

L. Sound level may not exceed sound levels listed in NEMA TR 1, without fans operating.

M. Impedance: +/- 7-1/2%.
Accessories: Grounding pads, lifting lugs, and provisions for jacking under base. Transformers shall have a steel base and frame allowing use of pipe rollers in any direction, and an insulated, low-voltage, neutral bushing with removable ground strap. Include the following additional accessories:

1. Transformer Temperature Controller that monitors transformer windings and ambient temperature. The unit shall provide Fans, Alarm, and Trip output relays. Form C contacts shall be provided to trip the transformer off-line if the winding temperature exceeds the trip setting. A 4-20 mA analog signal shall be provided for remote indication or for use with SCADA systems. Control power shall be provided from internal control power transformer.
2. Ventilation grilles.
4. Core ground strap.
5. Two stainless steel ground pads.
6. Diagrammatic nameplate.
7. Alarm contacts for gages and thermometer listed above.
8. SCADA interface.

2.4 PAD-MOUNTED, LIQUID-FILLED TRANSFORMERS


B. Insulating Liquid: Less flammable, silicone-based dielectric and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be FM approved and have low toxicity and be nonhazardous.

C. Insulation Temperature Rise: 65 deg C when operated at rated kVA output in a 40 deg C ambient temperature. Transformer shall be rated to operate at rated kilovolt ampere in an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C without loss of service life expectancy.

D. High-voltage and low-voltage windings shall be copper. Insulation between layers of the windings shall be by thermally set insulating paper or equal.

E. Basic Impulse Level: [60 for 5 kV] [95 for 15 kV].

F. Impedance: +/- 7-1/2%.

G. Full-Capacity Voltage Taps: Four 2.5 percent taps, 2 above and 2 below rated high voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.

H. Primary fusing: (Select) Provide [full-range, current limiting fuses in [load-break] [non-load break] drywell canisters] [oil-immersed, load-break bay-o-net overload sensing fuses in series with under oil partial range current limiting fuses].

I. Surge Arresters: Distribution class, one for each primary phase; complying with IEEE C62.11 and NEMA LA 1; support from tank wall within high-voltage compartment.

J. High-Voltage Terminations and Equipment: (Select) [Live front with externally clamped, wet process, porcelain bushings and cable connectors suitable for terminating primary
(Select paragraph K or L below per project requirements.)

K. Where a radial feed switch is shown on the drawings, provide a two-position, oil-immersed, gang-operated, rotary load-break switch. The switch mechanism shall be spring loaded and the operation shall be independent of operator speed. The switch shall have the following ratings:

1. Continuous current [200] [600] amperes. Momentary current 10,000 amps symmetrical (2 seconds). Make and latch 6,000 amps symmetrical. Load interrupting [200] [600] amps.

L. Where a loop-feed operation (sectionalizing switch) is shown on the drawings, provide a four-position configuration arrangement, oil-immersed, gang-operated, rotary, load-break switch. The switch mechanism shall be spring-loaded and the operation shall be independent of operator speed. The switch shall have the following ratings:

1. Continuous current 600 amperes, Maximum phase-to-phase 15 kV, maximum phase-to-ground 8.3 kV, Momentary 10,000 amps for 10 cycles symmetrical.

M. Accessories:

1. Drain Valve: 1 inch (25 mm), with sampling device.
2. Dial-type thermometer.
3. Liquid-level gage.
4. 1 inch upper filter press and filling plug.
5. Pressure-vacuum gage.
7. Mounting provisions for low-voltage current transformers. [Delete If Not Required]
8. Mounting provisions for low-voltage potential transformers. [Delete If Not Required]
9. Alarm contacts for gages and thermometer listed above.
10. SCADA interface.
11. Additional nameplate with FM approval data.
12. ANSI tank grounding provisions shall be furnished in both compartments.

2.5 NETWORK COMMUNICATIONS

A. Coordinate remote monitoring communication module package with the University’s SCADA system for successful transmission and remote readout of monitoring data.

B. Connect remote monitoring communication modules to the University’s SCADA system through appropriate network interface unit.

C. The manufacturer shall wire between all communications capable devices within the transformer, including electronic meters, with the same protocol and wire to a set of easily accessible terminal blocks.

2.6 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."
2.7 SOURCE QUALITY CONTROL

A. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to IEEE C57.12.90 for liquid filled transformers and C57.12.91 for dry types.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for medium-voltage transformers.

B. Examine roughing-in of conduits and grounding systems to verify the following:
   1. Wiring entries comply with layout requirements.
   2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders will have to cross section barriers to reach load or line lugs.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and that requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install pad mounted transformers on concrete bases designed by a Structural Engineer retained by the Contractor.

B. Install indoor transformers on 4-inch (100-mm) high (Evanston: 6" high east of Sheridan Rd.) concrete housekeeping pads.
   1. Anchor transformers to concrete pads according to manufacturer's written instructions.
   2. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Sections.
   3. Install dowel rods to connect concrete pad to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of pad.
   4. Install epoxy-coated anchor bolts, for supported equipment, that extend through concrete pad and anchor into structural concrete floor.
   5. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

C. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.
3.3 IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."

B. A laminated copy of the Material Safety Data Sheet (MSDS) for insulating fluid in liquid filled units shall be provided at the unit.

3.4 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Provide all communications wiring between remote monitoring and communication modules and the University’s SCADA system. Verify that each transformer's address for microprocessor-communication packages corresponds to data network requirements.

D. Verify tightness and torque all accessible bolted electrical connections to manufacturer's specified values using a calibrated torque wrench. Provide a list of all torqued connections and values.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. After installing transformers but before primary is energized, verify that grounding system at substation is tested at specified value or less.
2. After installing transformers and after electrical circuitry has been energized, test for compliance with requirements.
3. Perform visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

D. Test Reports: Prepare written reports to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective actions taken to achieve compliance with requirements.

E. Transformers shall not be permanently energized until all test reports have been submitted and approved by NU Electric Shop.
3.6 FOLLOW-UP SERVICE

A. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each transformer. Remove front and rear panels so joints and connections are accessible to portable scanner.

1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

2. Record of Infrared Scanning: Prepare a certified report that identifies transformer checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.

END OF SECTION 26 1200
PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:
      1. Distribution transformers.

1.3 ACTION SUBMITTALS
   A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.
   B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1.4 INFORMATIONAL SUBMITTALS
   A. Source quality-control test reports.
   B. Field quality-control test reports.
   C. Submit Letter of Compliance with DOE [2016].
   D. Submit certification of sound level compliance.

1.5 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE
   A. Source Limitations: Obtain each transformer type through one source from a single manufacturer.
B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

D. Comply with most current edition of the Northwestern University Design Standards.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.8 PROJECT CONDITIONS

A. (Delete This Paragraph If Not Required) [Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by The University or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify the University no fewer than [two] calendar weeks in advance of proposed interruption of electric service.
2. Indicate method of providing temporary utilities.
3. Do not proceed with interruption of electrical service without the University’s Chief Electrician’s written permission.
4. The University Lock-out/Tag-out procedures shall be used with Contractor controlled locks and tags.
5. Comply with NFPA 70E.]

B. Installation Pathway: Remove and replace building components and structures to provide pathway for moving transformers into place.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for transformers, including clearances between transformers and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:

1. Ambient Temperature: Not exceeding 40 deg C.

1.9 COORDINATION

A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Sections.
1.10 WARRANTY

A. Comply with Division 1 requirements.

B. Special Warranty: Manufacturer agrees to repair or replace Transformers that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Six years from date of Beneficial Occupancy.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following:
   1. Eaton Corp. Electrical Group
   2. Olsun Electrics.
   3. Siemens Inc.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Cores: Grain-oriented, non-aging silicon steel.

C. Coils: Continuous windings without splices except for taps.
   1. Internal Coil Connections: Terminals shall be welded to the leads of the coils. Terminals shall not be spot welded or bolted to the coil leads.
   2. Coil Material: Electrical grade Copper.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NEMA ST 20 and list and label as complying with UL 1561.

B. Cores: One leg per phase.

C. Enclosure, Indoors: Ventilated, NEMA 250, Type 2.
   1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

D. Transformer Enclosure Finish: Comply with NEMA 250.
   1. Finish Color: ANSI 61 gray.

E. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.

F. Insulation Class: 150 kVA and above - 220 deg C, UL-component-recognized insulation system with a maximum of 80 deg C rise above 40 deg C ambient temperature; 45 – 112.5 kVA and above - 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C
rise above 40 deg C ambient temperature; 30 kVA and below - 180 deg C, UL-component-recognized insulation system with a maximum of 150 deg C rise above 40 deg C ambient temperature.

G. Energy Efficiency for Transformers Rated 15 kVA and Larger:

H. K-Factor Rating: Transformers indicated to have a K-factor rating of K-13 and above shall comply with UL 1561 requirements for non-sinusoidal load current-handling capability to the degree defined by designated K-factor. Cores shall not be “oversized” to accommodate harmonics.

   1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
   2. Indicate value of K-factor on transformer nameplate.
   3. The neutral bus shall be configured to accommodate 200% of the rated current.

I. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize inter-winding capacitance.

   1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
   2. Include special terminal for grounding the shield.
   3. Shield Effectiveness:
      a. Capacitance between Primary and Secondary Windings: Not to exceed 33 picofarads over a frequency range of 20 Hz to 1 MHz.
      b. Common-Mode Noise Attenuation: Minimum of minus 120 dBA at 0.5 to 1.5 kHz; minimum of minus 65 dBA at 1.5 to 100 kHz.
      c. Normal-Mode Noise Attenuation: Minimum of minus 52 dBA at 1.5 to 10 kHz.

J. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

2.4 DRIVE ISOLATION TRANSFORMERS

A. Motor drive isolation transformers shall be designed for use with three-phase ac adjustable frequency drives 600 volts and below to provide isolation between the incoming line and drive circuitry. These drives minimize the line disturbances caused by SCR firing within the drive unit. Thermo-guards shall be included in all motor drive isolation transformers to provide additional protection for the transformer from increased heating due to the non-sinusoidal characteristics of drive currents. The transformer shall provide reduced short-circuit currents and voltage line transients. The transformer shall be specifically sized to the drive kVA requirements dictated by the horsepower of the motor and, as such, will be mechanically braced to withstand the stress of current reversals and short-circuit currents associated with the specific drive kVA rating. Transformers shall be low loss type with minimum efficiencies per NEMA TP-1 when operated at 35% of full load capacity.

2.5 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws.
B. Nameplate shall identify Transformer ID, primary voltage; secondary voltage; “Fed From…” and “Feeds…” shall be included.

C. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

2.6 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.91.

B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Construct concrete bases 4 inches larger than the footprint of the unit and 4 inches high (Evanston: 6” high east of Sheridan Rd.) for floor mounted transformers and anchor transformers to pad according to manufacturer's written instructions and requirements in Northwestern University Design Standards.

B. Do not install transformers in ceiling cavities or wall hang.

3.3 CONNECTIONS

A. Connection to Transformers: Flexible Metallic Conduit (FMC), primary and secondary.

B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
1. External cable shall be rated 90 degrees C (sized at 75 degrees C ampacity) for encapsulated and 75 degrees C for ventilated designs. Connectors should be selected on the basis of the type and cable size used to wire the specific transformer.

2. Verify tightness and torque all accessible bolted electrical connections to manufacturer’s specified values using a calibrated torque wrench.

3.4 IDENTIFICATION

A. Nameplates: Label each Transformer with a nameplate complying with requirements for identification specified in Division 26 Section “Identification for Electrical Systems,” including identification of the transformer, voltage characteristics, “Fed From…” and “Feeds…”.

3.5 FIELD QUALITY CONTROL

A. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Perform tests and inspections and prepare test reports.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

D. Remove and replace units that do not pass tests or inspections and retest as specified above.

E. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed “Satisfactory Test” label to tested component.

F. Transformers shall not be permanently energized until all test reports have been submitted and approved by NU Electric Shop.

3.6 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.


3.7 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 26 2200
SECTION 26 2300 - LOW-VOLTAGE SWITCHGEAR

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes metal-enclosed, low-voltage power circuit-breaker switchgear rated 1000 V and less for use in AC systems.

B. Related Sections include the following:

1. Division 26 Section "Surge Protective Devices for Low-Voltage Electrical Power Circuits" for transient voltage surge suppressors for low-voltage power, control, and communication equipment located in the switchgear.
2. Division 26 Section "Low Voltage Electrical Power Conductors and Cables".
3. Division 26 Section "Electricity Metering."
4. Division 26 Section "Grounding and Bonding for Electrical Systems".

1.3 ACTION SUBMITTALS

A. Product Data: For each type of switchgear, circuit breaker, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each type of switchgear and related equipment.

1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Include the following:

   a. Tabulation of installed devices with features and ratings.
   b. Enclosure types and details.
   c. Outline and general arrangement drawing showing dimensions, shipping sections, and weights of each assembled section.
   d. Bus configuration with size and number of conductors in each bus run, including phase, neutral, and ground conductors of main and branch buses.
   e. Current rating of buses.
   f. Short-time and short-circuit current rating of switchgear assembly.
   g. Nameplate legends.
   h. Mimic-bus diagram.
   i. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

2. Wiring Diagrams: Power, signal, and control wiring.
1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around switchgear where pipe and ducts are prohibited. Show switchgear layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

B. Field quality-control test reports.

C. Updated mimic-bus diagram reflecting field changes after final switchgear load connections have been made, for record.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchgear and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Six of each type and rating used. Include spares for potential transformer fuses and control power fuses.
2. Indicating Lights: Two of each type installed.
3. [Two sets of spare keys for Kirk Key interlocks. Keys shall be received and signed for by the University’s Chief Electrician.]

1.7 QUALITY ASSURANCE

A. Source Limitations: Obtain switchgear through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of switchgear and are based on the specific system indicated.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by UL and marked for intended use.

D. Comply with NFPA 70.

E. Comply with UL 1558.
F. Comply with most current edition of the Northwestern University Design Standards.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchgear in sections of lengths that can be moved past obstructions in delivery path.

B. Store switchgear indoors in clean dry space with uniform temperature to prevent condensation. Protect switchgear from exposure to dirt, fumes, water, corrosive substances, and physical damage.

C. If stored in areas subjected to weather, cover switchgear to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchgear; install electric heating (250 W per section) to prevent condensation.

1.9 PROJECT CONDITIONS

A. *(Delete This Paragraph If Not Required)* [Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by The University or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:]

1. Notify the University’s Chief Electrician no fewer than [two] calendar weeks in advance of proposed interruption of electric service.
2. Indicate method of providing temporary utilities.
3. Do not proceed with interruption of electrical service without the University’s Chief Electrician’s written permission.
4. The University Lock-out/Tag-out procedures shall be used with Contractor controlled locks and tags.
5. Comply with NFPA 70E.]

B. Installation Pathway: Remove and replace building components and structures to provide pathway for moving switchgear into place.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchgear, including clearances between switchgear and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:

1. Ambient Temperature: Not exceeding 40 deg C.

1.10 COORDINATION

A. Coordinate sensor-communication module package with data network and with the University’s SCADA system for successful transmission and remote readout of remote monitoring data specified in this Section.
B. Coordinate layout and installation of switchgear and components with other construction that penetrates ceilings or is supported by them, including conduit, piping, equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels.

C. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Sections.

1.11 WARRANTY

A. Comply with Division 1 requirements.

B. Special Warranty: Manufacturer agrees to repair or replace components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Beneficial Occupancy.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2. Siemens Industry Inc.
3. Equal as approved by University’s Chief Electrician.

2.2 RATINGS

A. Nominal System Voltage 480/277 V, 4 wire, 60 Hz.

B. Main-Bus Continuous: <Insert size> A.

C. Short-Time and Short-Circuit Current: Match rating of highest-rated circuit breaker in switchgear assembly.

2.3 FABRICATION

A. Factory assembled and tested and complying with ANSI/IEEE C37.20.1 and UL 1558.

B. Indoor Enclosure Material: Steel.

C. Finish: ANSI/IEEE C37.20.1, manufacturer's standard gray finish over a rust-inhibiting primer on phosphatizing-treated metal surfaces.

D. Section barriers between main and tie circuit-breaker compartments shall be extended to rear of section.

E. Bus isolation barriers shall be arranged to isolate line bus from load bus at each main and tie circuit breaker.
F. Circuit-breaker compartments shall be equipped to house drawout-type circuit breakers and shall be fitted with hinged outer doors.

G. Fabricate enclosure with removable, hinged, rear cover panels to allow access to rear interior of switchgear with Corbin #4T3142 key lock. Lock type shall be the same for both campuses.

H. Inspection windows, 4” diameter, in rear panels to permit thermal imaging of device terminations, with sliding cover.

I. Auxiliary Compartments: Match and align with basic switchgear assembly. Include the following:
   1. Bus transition sections.
   2. Incoming-line sections.
   3. Hinged front panels for access to metering, accessory, and blank compartments.

J. Bus bars connect between vertical sections and between compartments. Cable connections are not permitted.
   1. Main Phase Bus: Uniform capacity the entire length of assembly.
   3. Vertical Section Bus Size: Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers.
   5. Use copper for connecting circuit-breaker line to copper bus.
   6. Contact Surfaces of Buses: Silver plated.
   7. Feeder Circuit-Breaker Load Terminals: Silver-plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.
   8. Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for feeder and branch-circuit ground conductors, minimum size 1/4 by 2 inches (6 by 50 mm).
  10. Service Entrance shall comply with UL Service Entrance requirements: service entrance label, incoming line isolation barriers, neutral connection to switchgear ground for solidly grounded wye systems.
  11. Neutral bus equipped with pressure-connector terminations for outgoing circuit neutral conductors. Neutral-bus extensions for busway feeders are braced.
  12. Neutral Disconnect Link: Bolted, un-insulated, 1/4-by-2-inch (6-by-50-mm) copper bus, arranged to connect neutral bus to ground bus.
  13. Provide for future extensions from either end of main phase, neutral, and ground bus by means of predrilled bolt-holes and connecting links.
      a. Sprayed Insulation Thickness: 3 mils (0.08 mm), minimum.
      b. Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.
2.4 COMPONENTS

A. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks. Meters are described in Division 26 Section “Electricity Metering”.

   1. Potential Transformers: Secondary-voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
   2. Current Transformers: Ratios as indicated; burden and accuracy class suitable for connected relays, meters, and instruments.

C. Comply with Section 26 2713 “Electricity Metering” requirements.

D. Multifunction Digital-Metering Monitor: UL-listed or -recognized, microprocessor-based unit suitable for three- or four-wire systems and with the following features:
   1. Comply with Section 26 2713 “Electricity Metering” requirements.
   2. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
   3. Selectable digital display of the following:
      a. Accuracy: Power meter shall meet ANSI C12.20 for Class 2 and IEC 62053-22 accuracy requirements.
      b. Phase Currents, Each Phase.
      c. Phase-to-Phase Voltages, Three-Phase.
      d. Phase-to-Neutral Voltages, Three-Phase.
      e. Three-Phase Real Power.
      f. Three-Phase Reactive Power.
      g. Power Factor.
      h. Frequency.
      i. Power demand shall be simultaneously calculated using five different averaging methods: Fixed Window (Block) Average, Sliding Window (Rolling Block) Average, Thermal Average, Predicted Average, and Cumulative Demand. Values for all averaging intervals must be available simultaneously.
      j. Accumulated Watt-hr, VA-hr, and VAR-hr; Watt-hr received; Watt-hr delivered.

4. Metering Compartment: Provide 6 port Ethernet switch, graphic display module, meter, gateway, RJ45 to RJ45 receptacle, 120 VAC to 12 VDC power supply. Display and control unit flush or semi-flush mounted in instrument compartment door.

E. [Utility metering compartment: A separate Com-Ed utility metering compartment and section with front hinged door, for indicated metering. Comply with requirements of electrical-power Utility Company.]

F. Programmable pulse values from customer and utility meters shall report to the University’s SCADA system through a web enabled pulse data logger. Data pulses shall be captured in real time and reported via email ftp or web service.

G. Relays: Comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.

I. Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.

J. Control Power Supply: Control power transformer supplying 120-V control circuits through secondary disconnect devices. Include the following features:

1. Dry-type transformers, in separate compartments for units larger than 3 kVA, including primary and secondary fuses.
2. **[Provide for electrically interlocked main-tie-main arrangements]** Two control power transformers in separate compartments with necessary interlocking relays; each transformer connected to line side of associated main circuit breaker.
   a. Secondary windings connected through a relay or relays to control bus to affect an automatic transfer scheme.
   b. Secondary windings connected through an internal automatic transfer switch to switchgear control power bus.
4. Fuses are specified in Division 26 Section "Fuses."

K. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:

1. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
2. Conductors sized according to NFPA 70 for duty required.

2.5 CIRCUIT BREAKERS

A. Description: Comply with IEEE C37.13 AND UL 1066.

1. Eaton “Magnum DS” or equal by Siemens.

B. Ratings: As indicated, fully rated, for continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear.

C. Main and Tie circuit breakers shall have a minimum 3200 A frame.

D. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:

1. Normal Closing Speed: Independent of both control and operator.
2. Slow Closing Speed: Optional with operator for inspection and adjustment.
3. Stored-Energy Mechanism: **[Manually charged]** **[Electrically charged, with optional manual charging (For ‘Main-Tie-Main’ Arrangements)]**.
4. Operation counter.

E. Trip Devices: Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features:
1. Eaton Digi-Trip 1150 plus or equal.
2. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
3. Minimum sensor size shall be 800 A which can be set at 50 percent of breaker rating.
4. Temperature Compensation: Ensures accuracy and calibration stability from minus 5 to plus 40 deg C.
5. Field-adjustable, time-current characteristics.
6. Current Adjustability: Dial settings and rating plugs on trip units or sensors on circuit breakers, or a combination of these methods.
7. Three bands, minimum, for long-time- and short-time-delay functions; marked “minimum,” “intermediate,” and “maximum.”
10. Ground-fault protection with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup. Arrange to provide protection for the following:
   a. Three-wire circuit or system.
   b. Four-wire circuit or system.
   c. Four-wire, double-ended substation.
11. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.
12. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking phase and ground-fault protection function with the downstream circuit breakers so that the breaker closest to the fault will clear the fault without disruption of service to other parts of the distribution system.
13. Maintenance mode switched trip units: The trip unit shall utilize Arc Flash Reduction Maintenance System to reduce the instantaneous pickup value when activated. The ARMS shall provide a clearing time of 0.04 seconds with a minimum of settings from 2.5X to 10X of the sensor value. The ARMS shall be enabled by a switch on the trip unit with blue indicator LED. A remote communication link shall also be provided for enable/disable and confirmation.

F. Phase rotation indicators: Bright LED lamps indicate phase live or open, correct phase sequence, with fuse protected inputs. Provide on each main.

G. Communication Capability: Communication modules with functions and features compatible with the University’s SCADA system using Modbus or Ethernet, such as power and voltage metering, power quality monitoring, access to programmable trip settings, breaker control, alarm status, and diagnostic information.

H. Auxiliary Contacts: For interlocking or remote indication of circuit-breaker position, with spare auxiliary switches and other auxiliary switches required for normal circuit-breaker operation, quantity as indicated. Each consists of two-type “a” and two-type “b” stages (contacts) wired through secondary disconnect devices to a terminal block in stationary housing.

I. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in connected, test, and disconnected positions. Include the following features:
   1. Interlocks: Prevent movement of circuit breaker to or from connected position when it is closed, and prevent closure of circuit breaker unless it is in connected, test, or disconnected position.
2. Circuit-Breaker Positioning: An open circuit breaker may be racked to or from connected, test, and disconnected positions only with the associated compartment door closed unless live parts are covered by a full dead-front shield. An open circuit breaker may be manually withdrawn to a position for removal from the structure with the door open. Status for connection devices for different positions includes the following:
   
   a. Test Position: Primary disconnect devices disengaged, and secondary disconnect devices and ground contact engaged.
   b. Disconnected Position: Primary and secondary devices and ground contact disengaged.

J. Arc Chutes: Readily removable from associated circuit breaker when it is in disconnected position, and arranged to permit inspection of contacts without removing circuit breaker from switchgear.

K. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism. Provisions shall be included for padlocking the breaker in the open or closed position.

L. Operating Handle: One for each circuit breaker capable of manual operation.

M. Electric Close Button: One for each electrically operated circuit breaker.

N. Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks.

O. (Delete This Paragraph For Single Ended Switchgear) Key Interlocks: Arranged so keys are attached at devices indicated and requires one main circuit breaker in a double-ended unit substation to be open before the tie circuit breaker can be closed. Mountings and hardware are included where future installation of key-interlock devices is indicated. These interlocks shall keep the circuit breakers trip-free when actuated.

P. (Delete If Not Required) (Undervoltage Trip Devices: Where indicated, adjustable time-delay and pickup voltage.)

Q. Shunt-Trip Devices: Provide on source breakers for Closed Transition Transfer Switches.

R. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices.

S. Lugs: Mechanical style, rated for Copper conductors only, suitable for number, size, and trip ratings.

T. Grounding Ball Studs: provide on incoming lug pad and outgoing lug pad.

U. Provide shorting blocks for maintenance.

V. (For Main-Tie-Main arrangements) (Kirk Key Interlocks: Key interlocks shall be provided as indicated on the drawings. Arrange so keys are attached at devices indicated. These interlocks shall keep the circuit breakers trip-free when actuated. Mountings and hardware are included where future installation of key-interlock devices is indicated.)
2.6 SPACE FOR FUTURE DEVICES

A. Where indicated on the Drawings, "space" shall mean fully provisioned space ready for inserting a circuit breaker at a future date without any future modifications. Provide current transformers sized according to the breaker frame size. A blank door shall close off the front of the compartment.

2.7 TIE BREAKER CONTROL *(Delete Paragraphs A thru E If Switchgear Is Single Ended)*

A. Provide automatic transfer control equipment to transfer a load bus from its normal source of supply to an alternate source. Voltage sensing on each source shall be three phase with loss of phase protection. All transfer scheme logic shall be incorporated into and executed by a Programmable Logic Controller (PLC). The PLC shall receive the following inputs: source voltage status as sensed by the voltage relays, breaker status (open, closed, tripped on fault) for main and bus tie breakers. Interposing relays shall be provided for interfacing the PLC outputs with the circuit breaker close and trip circuits. Additional PLC outputs shall be provided for local indication of the following: transfer scheme status (auto-blue / manual-white) and PLC fault (amber). If the control power source for the PLC is derived from within the switchgear, provide a dedicated "hold up device" for the PLC to ride through any momentary switching of control power sources. The PLC programs shall be executed without interruption during an undervoltage or loss of phase condition.

B. Basic PLC logic features shall include: interlocking of the main and bus tie breakers to prevent paralleling sources; time delay for initiating a transfer upon an undervoltage or loss of phase condition; time delay for return to normal after the undervoltage or loss of phase condition has been corrected; and blocking transfer, if the main or bus tie breaker trips due to a fault.

C. Description of operation - three breaker transfers (main-tie-main), delayed transfer / delayed return. Under normal conditions both main breakers are closed and the bus tie breaker is open. The transfer system selector switch is in the auto position. When an undervoltage or loss of phase condition is detected, the PLC receives an input from the voltage sensing relays. The PLC program executes, tripping the affected main breaker by its interposing trip relay after the programmed time delay. The PLC senses the open main breaker status and the program immediately closes the bus tie breaker by its interposing close relay. With the return of the affected source, the PLC trips the bus tie breaker by its interposing trip relay after the programmed time delay. The PLC senses the open tie breaker and the program immediately recloses the open main breaker by its interposing relay. Simultaneous loss of both sources shall not cause any change in breaker status. Upon return of one source, the PLC shall immediately trip the main breaker without voltage and close the bus tie breaker.

D. Manual operation - Control switches for the main and bus tie breakers are inoperative when the transfer system control selector switch is in the auto position. Turning the transfer system control selector switch to the manual position allows the main and bus tie breakers to be manually closed and tripped via their control switches. Electrical interlocking in the breaker close circuits prevents both main breakers and the tie breaker from being closed at the same time. Redundant electrical interlocking, separate from the PLC, shall be provided for the main and tie breakers and shall be operational only when the automatic transfer system is in the manual mode. To transfer the loads from one source to the other, the affected main breaker must first be opened and then the bus tie breaker can be manually closed. To return to normal, trip the bus tie breaker and reclose the main breaker via their respective control switches.

E. The PLC shall be able to communicate via RS-485 / Modbus RTU protocol.
2.8 ACCESSORIES

A. Accessory Set: Furnish tools and miscellaneous items required for circuit-breaking and switchgear test, inspection, maintenance, and operation.

1. Racking handle to manually move circuit breaker between connected and disconnected positions.
2. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear.
3. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.

B. Circuit-Breaker Removal Apparatus: Overhead-circuit-breaker lifting device, track mounted at top front of switchgear and complete with hoist and lifting yokes matching each size of drawout circuit breaker installed.

C. Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

2.9 NETWORK COMMUNICATIONS

A. Coordinate remote metering communication module package with the University’s SCADA system for successful transmission and remote readout of monitoring data.

B. Connect remote metering communication modules to the University’s SCADA system through appropriate network interface unit.

C. The manufacturer shall wire between all communications capable devices within the switchgear, including electronic meters with the same protocol and wire to a set of easily accessible terminal blocks.

2.10 IDENTIFICATION

A. Mimic Bus: Continuously integrated mimic bus factory applied to front of switchgear. Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic-bus diagram.

1. Mimic-bus segments coordinated with devices in switchgear sections to which applied, to produce a concise visual presentation of principal switchgear components and connections.
3. Color: As selected by University, contrasting with factory-finish background to represent bus and components.

B. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

C. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.
D. Switchgear Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

E. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

F. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads. Include as-built data for low-voltage power switchgear and connections as follows:

1. Frame size of each circuit breaker.
2. Trip rating for each circuit breaker.
3. Conduit and wire size for each feeder.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces where switchgear will be installed for compliance with installation tolerances, required clearances, and other conditions affecting performance.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with applicable portions of NECA 400.

B. Anchor switchgear assembly to concrete base and attach by bolting.

1. Concrete Bases: 4 inches (100 mm) high, (Evanston: 6” high east of Sheridan Rd.) reinforced, with chamfered edges. Extend base no more than 3 inches (75 mm) in all directions beyond the maximum dimensions of switchgear unless otherwise indicated. Construct concrete bases according to Division 3 Concrete Sections.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, brackets, and temporary blocking of moving parts from switchgear units and components.

D. Provide wall mounted cabinet with lockable hinged door, to store all accessories, test equipment, small spares, operating and maintenance manuals, and maintenance ledger in same room as equipment.

E. [Clear working space around switchgear shall be in accordance with City of Chicago Electric Code.]

F. [Install meters furnished by Utility Company. Install raceways and equipment according to utility company's written requirements. Provide empty conduits for metering leads and extend grounding connections as required by Utility Company.]
3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning
signs as specified in Division 26 Section "Identification for Electrical Systems."

B. Arc Flash Labels: provide as specified in Division 26 Section "Identification for Electrical
Systems."

C. Diagram and Instructions:
   1. Frame and mount under clear acrylic plastic on the front of switchgear or on nearest
      adjacent wall.
      a. Operating Instructions: Printed basic instructions for switchgear, including control
         and key-interlock sequences and emergency procedures.
      b. System Power Riser Diagrams: Depict power sources, feeders, distribution
         components, and major loads.

3.4 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical
Systems."

B. Bond conduits entering underneath the switchboard to the equipment ground bus with a
bonding conductor sized per NFPA 70.

C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and
Cables."

D. Verify tightness and torque all accessible bolted electrical connections to manufacturer’s
specified values using a calibrated torque wrench. Provide a list of all torqued connections and
values.

E. Provide all communications wiring between remote metering and communication modules and
the University’s SCADA system. Verify that each circuit breaker’s address for microprocessor-
communication packages corresponds to data network requirements. Programmable pulse
values shall report to the University’s SCADA system. Include all necessary programming by
factory certified technician.

3.5 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:
   1. Test insulation resistance for each switchgear bus, component, connecting supply,
      feeder, and control circuit.
   2. Test continuity of each circuit.

B. Manufacturer’s Field Service: Engage a factory-authorized service representative to perform
the following:
   1. Inspect switchgear installation, including wiring, components, connections, and
      equipment. Test and adjust components and equipment.
2. Verify that electrical control wiring installation complies with manufacturer's submittal by means of point-to-point continuity testing. Verify that wiring installation complies with requirements in Division 26 Sections.

3. Complete installation and startup checks according to manufacturer's written instructions.

4. Assist in field testing of equipment including pretesting and adjusting of equipment and components.

5. Report results in writing.

C. Perform the following field tests and inspections and prepare test reports:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for each of the following NETA categories:
   a. Switchgear.
   b. Circuit breakers.
   c. Protective relays.
   d. Instrument transformers.
   e. Metering and instrumentation.
   f. Ground-fault systems.
   g. Surge arresters.

2. Remove and replace malfunctioning units and retest as specified above.

D. Infrared Scanning: After Substantial Completion, but not more than 90 days after Final Acceptance, perform an infrared scan of each switchgear line-up. Remove front and rear panels so joints and connections are accessible to portable scanner.

1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

2. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.

4. Submit reports to NU Electric Shop.

3.6 ADJUSTING

A. Set field-adjustable, protective-relay trip characteristics as specified in the "Overcurrent Protective Device Coordination Study." Provide list of "as left" settings and submit to Electric Shop and include in O & M manuals.

3.7 CLEANING

A. On completion of installation, inspect interior and exterior of switchgear. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.
3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train the University's maintenance personnel to adjust, operate, and maintain switchgear.

END OF SECTION 26 2300
LOW-VOLTAGE SWITCHGEAR
SECTION 26 2413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Service and distribution switchboards rated 600 V and less.
   2. Surge suppression devices.
   3. Disconnecting and overcurrent protective devices.
   4. Instrumentation.
   5. Control power.
   6. Accessory components and features.
   7. Identification.
   8. Mimic bus.

B. Related Sections include the following:
   1. Division 26 Section "Surge Protective Devices for Low-Voltage Electrical Power Circuits" for transient voltage surge suppressors for low-voltage power, control, and communication equipment located in the switchgear.
   2. Division 26 Section "Low Voltage Electrical Power Conductors and Cables".
   3. Division 26 Section "Grounding and Bonding for Electrical Systems".

1.3 ACTION SUBMITTALS

A. Product Data: For each type of switchboard, overcurrent protective device, surge suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers’ technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.

   1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
   2. Detail enclosure types for types other than NEMA 250, Type 1.
   3. Detail bus configuration, current, and voltage ratings.
   5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

7. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.

8. Include diagram and details of proposed mimic bus.

9. Include schematic and wiring diagrams for power, signal, and control wiring.

C. Samples: Representative portion of mimic bus with specified material and finish, for color selection.

1.4 INFORMATIONAL SUBMITTALS

A. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. In addition include the following:

1. Routine maintenance requirements for switchboards and all installed components.
2. Manufacturer’s written instructions for testing and adjusting overcurrent protective devices.
3. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Six of each type and rating used. Include spares for potential transformer fuses and control power fuses.
2. Indicating Lights: Two of each size and type.
3. [Two sets of spare keys for Kirk Key interlocks. Keys shall be received and signed for by the University’s Chief Electrician.]

1.7 QUALITY ASSURANCE

A. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 by UL and marked for intended location and application.
C. Use of series rated equipment is prohibited.

D. Comply with NEMA PB 2.

E. Comply with NFPA 70.

F. Comply with UL 891.

G. Comply with most current edition of the Northwestern University Design Standards.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Remove loose packing and flammable materials from inside switchboards.

C. Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.9 PROJECT CONDITIONS

A. (Delete This Paragraph If Not Required) [ Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by the University or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify the University’s Chief Electrician no fewer than [two] calendar weeks in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electrical service without the University’s Chief Electrician’s written permission.
4. The University Lock-out/Tag-out procedures shall be used with Contractor controlled locks and tags.
5. Comply with NFPA 70E.]

B. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

C. Environmental Limitations:

1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
   a. Ambient Temperature: Not exceeding 104 deg F (40 deg C).

D. Service Conditions: NEMA PB 2, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet (2000 m).

E. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards, including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.10 COORDINATION

A. Coordinate sensor-communication module package with data network and with the University’s SCADA system for successful transmission and remote readout of remote monitoring data specified in this Section.

B. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

C. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Sections.

1.11 WARRANTY

A. Special Warranty: Manufacturer’s standard form in which manufacturer agrees to repair or replace components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: **Six** years from date of Beneficial Occupancy.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2. Siemens Industry Inc.

B. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: [Draw-out] [Fixed, individually mounted, insulated case].
3. Sections front and rear aligned.

C. Front- and Rear-Accessible Switchboards:

1. Main Devices: [Drawout] [Fixed, individually mounted insulated case].
2. Branch Devices: Panel and fixed, individually mounted.
3. Sections front and rear aligned.
D. Nominal System Voltage: [480Y/277 V] [208Y/120 V].

E. Main-Bus Continuous: <Insert ampere rating> A. [Note: 2000 A maximum]

F. Factory certified 30 cycle rating.

G. Indoor Enclosures: 12 gauge Steel, NEMA 250, and Type 1.

H. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

I. Barriers: Between adjacent switchboard sections.

J. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.

K. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

L. Rear Accessible Switchboards: Hinged Rear Doors and Compartment Covers to allow access to rear interior of Switchboard with Corbin #4T3142 key lock as approved by NU Electric Shop. Lock type shall be the same for both campuses.

M. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments, held with knurled thumb screw retainers.

N. Provide IR scanning windows in switchboard dead front to allow scan of line and load side lugs, and bolted connections.

O. Buses and Connections: Three-phase, four-wire unless otherwise indicated.


2. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with mechanical connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position, plug-in, finger type bus connections are not acceptable.

3. Make all bus connections using a minimum of two (2) Grade 5 bolts with conical washers.


5. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.

6. Neutral Buses: Tin-plated, 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables.


P. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

Q. Optional [Furnish switchboard with all provisions necessary for future extension of buswork and enclosure, if not double ended equipment.]
R. Optional [Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.]

2.2 TRANSIENT VOLTAGE SUPPRESSION DEVICES

A. Surge Protection Device Description: IEEE C62.41-compliant externally mounted, UL 1449 3rd edition, short-circuit current rating matching or exceeding the switchboard short-circuit rating, and with the following features and accessories:

1. Comply with Division 26 Section “Surge Protective Devices”.
2. Provide a dedicated three pole circuit breaker for the SPD in the switchboard.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2. Siemens Industry Inc.
3. Gus Berthold Electric with Eaton Corp. or Siemens Industry Inc. components

B. Molded-Case Circuit Breaker (MCCB) Up To 1600 A: Comply with UL 489, fully rated to meet available fault currents. Use of series rated equipment is prohibited.

1. Circuit breakers 600 Amps and greater shall be insulated molded case.
2. Minimum frame size shall be 400 Amps for feeders and 800 Amps for Mains or Tie.
3. Circuit breakers 400 Amps and greater shall be rated to carry 100% of nameplate rating continuously.
5. Electronic trip circuit breakers 225 A and larger shall have RMS sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:

   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long- and short-time time adjustments.
   d. Ground-fault pickup level, time delay, and I²t response.

6. Molded-Case Circuit-Breaker (MCCB) Features and Options:

   a. Standard frame sizes, trip ratings, and number of poles.
   b. Lugs: Mechanical style, rated Copper only, suitable for number, size, and trip ratings.

      (Edit For Project Requirements)

   c. Ground-Fault Protection: Integrrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   d. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
   e. Communication Capability: Communication modules with functions and features compatible with the University’s SCADA system.
f. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage. Provide for source breakers for Closed Transition Transfer Switches.

g. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.

h. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

i. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

2.4 CIRCUIT BREAKERS – MAIN DEVICES 1600A THROUGH 2000A

A. Description: Comply with IEEE C37.13 and .16 and UL 1066.

1. Eaton “Magnum SB” or equal by Siemens, draw out type insulated case power circuit breaker.

B. Ratings: As indicated, fully rated, for continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear.

1. Minimum frame size shall be 1600 A.

C. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:

1. Normal Closing Speed: Independent of both control and operator.
2. Slow Closing Speed: Optional with operator for inspection and adjustment.
3. Stored-Energy Mechanism: [Electrically charged, with optional manual charging (For 'Main-Tie-Main' Arrangements)].
4. Position status reports through University's SCADA system.
5. Operation counter.

D. Trip Devices: Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features:

1. Eaton “Digi-Trip 1150” plus or equal.
2. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
3. Temperature Compensation: Ensures accuracy and calibration stability from minus 5 to plus 40 deg C.
4. Field-adjustable, time-current characteristics.
5. Current Adjustability: Dial settings and rating plugs on trip units or sensors on circuit breakers, or a combination of these methods.
6. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
8. Pickup Points: Five minimum, for instantaneous-trip functions.
9. Ground-fault protection with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup. Arrange to provide protection for the following:

   a. Three-wire circuit or system.
   b. Four-wire circuit or system.
c. Four-wire, double-ended substation.

10. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.

11. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking phase and ground-fault protection function.

12. Maintenance mode switched trip units: The trip unit shall utilize Arc Flash Reduction Maintenance System (ARMS) to reduce the instantaneous pickup value when activated. The ARMS shall provide a clearing time of 0.04 seconds with a minimum of settings from 2.5X to 10X of the sensor value. The ARMS shall be enabled by a switch on the trip unit with blue indicator LED. A remote communication link shall also be provided for enable/disable and confirmation.

E. Communication Capability: Communication modules with functions and features compatible with the University’s SCADA system using Modbus or Ethernet, such as power and voltage metering, power quality monitoring, access to programmable trip settings, breaker control, alarm status, and diagnostic information.

F. Auxiliary Contacts: For interlocking or remote indication of circuit-breaker position, with spare auxiliary switches and other auxiliary switches required for normal circuit-breaker operation, quantity as indicated. Each consists of two-type “a” and two-type “b” stages (contacts) wired through secondary disconnect devices to a terminal block in stationary housing. Reports through University’s SCADA system.

G. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in connected, test, and disconnected positions. Include the following features:

1. Interlocks: Prevent movement of circuit breaker to or from connected position when it is closed, and prevent closure of circuit breaker unless it is in connected, test, or disconnected position.

2. Circuit-Breaker Positioning: An open circuit breaker may be racked to or from connected, test, and disconnected positions only with the associated compartment door closed unless live parts are covered by a full dead-front shield. An open circuit breaker may be manually withdrawn to a position for removal from the structure with the door open. Status for connection devices for different positions includes the following:

   a. Test Position: Primary disconnecting devices disengaged and secondary disconnect devices and ground contact engaged.

   b. Disconnected Position: Primary and secondary devices and ground contact disengaged.

H. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism. Provisions shall be included for padlocking the breaker in the open or closed position.

I. Operating Handle: One for each circuit breaker capable of manual operation.

J. Electric Close Button: One for each electrically operated circuit breaker.

K. Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks.
L. *For Main-Tie-Main arrangements* [Kirk Key Interlocks: Key interlocks shall be provided as indicated on the drawings. Arrange so keys are attached at devices indicated. These interlocks shall keep the circuit breakers trip-free when actuated. Mountings and hardware are included where future installation of key-interlock devices is indicated.]

M. Undervoltage Trip Devices: Where indicated, adjustable time-delay and pickup voltage.

N. Shunt-Trip Devices: Where indicated.

O. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices.

P. Lugs: Mechanical style, rated for Copper conductors only, suitable for number, size, and trip ratings.

Q. Grounding Ball Studs: provide on incoming lug pad and outgoing lug pad.

R. Provide fused shorting blocks for maintenance.

2.5 INSTRUMENTATION

A. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks. Meters are described in Division 26 Section “Electricity Metering”.

B. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:

1. Potential Transformers: IEEE C57.13; 120 V, 60 Hz, disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.

2. Current Transformers: IEEE C57.13; 5 Amp, 60 Hz, secondary and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.

3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.


C. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for four-wire systems and with the following features:

1. Comply with Section 26 2713 “Electricity Metering” requirements.

2. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.

3. Selectable digital display of the following values with maximum accuracy tolerances as indicated:
a. Accuracy: Power meter shall meet ANSI C12.20 for Class 2 and IEC 62053-22 accuracy requirements.
b. Phase Currents, Each Phase.
c. Phase-to-Phase Voltages, Three-Phase.
d. Phase-to-Neutral Voltages, Three-Phase.
e. Three-Phase Real Power.
f. Three-Phase Reactive Power.
g. Power Factor.
h. Frequency.
i. Power demand shall be simultaneously calculated using five different averaging methods: Fixed Window (Block) Average, Sliding Window (Rolling Block) Average, Thermal Average, Predicted Average, and Cumulative Demand. Values for all averaging intervals must be available simultaneously.
j. Accumulated Watt-hr, VA-hr, and VAR-hr; Watt-hr received; Watt-hr delivered.
k. Contact devices to operate remote impulse-totalizing demand meter.

4. Mounting: Display and control unit flush or semi-flush mounted in instrument compartment door.

2.6 NETWORK COMMUNICATIONS

A. Coordinate remote metering and communication module package with the University’s SCADA system for successful transmission and remote readout of monitoring data.

B. Connect remote metering and communication modules to The University’s SCADA system through appropriate network interface unit.

C. The manufacturer shall wire between all communications capable devices within the switchboard, including electronic meters with the same protocol and wire to a set of easily accessible terminal blocks.

2.7 CONTROL POWER

A. Control Circuits: 120-VAC, supplied through secondary disconnecting devices from control-power transformer.

B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

C. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.8 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

2.9 IDENTIFICATION

A. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on an engraved laminated-plastic nameplate.

B. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce a concise visual presentation of principal switchboard components and connections.

C. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components complete with lettered designations.

D. Service Equipment Label: UL labeled for use as service equipment where required.

E. Each vertical section is to be labeled with the vertical bus voltage, amperage, phase, and fault current bracing rating.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged. Scratches and small dents shall be repaired as approved by NU Chief Electrician.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install switchboards and accessories according to NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete bases, 4-inch (100-mm) nominal thickness (Evanston: 6" east of Sheridan Rd.). Extend base no more than 3 inches (75 mm) in all directions beyond the maximum dimensions of switchboards unless otherwise indicated. Comply with requirements specified in Division 03 Concrete Sections.

1. Install dowel rods to connect concrete base to concrete floor on 18-inch (450-mm) centers around the full perimeter of concrete base.

2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor, install to elevations required for proper attachment to switchboards.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

D. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

E. Provide wall mounted cabinet with lockable hinged door, to store all accessories, test equipment, small spares, operating and maintenance manuals, and maintenance ledger in same room as equipment.

F. Install filler plates in unused spaces of panel-mounted sections.

G. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.

H. Install externally mounted Surge Protection Devices. Lead length not to exceed 36 inches.

I. Verify tightness and torque all accessible bolted electrical connections to manufacturer’s specified values using a calibrated torque wrench.

J. Double lugging on one protective device to feed two (2) separate loads is not permitted.

K. Comply with NECA 1.

3.3 CONNECTIONS

A. Ground equipment according to Division 26 Section “Grounding and Bonding for Electrical Systems.”

B. Connect wiring according to Division 26 Section “Low-Voltage Electrical Power Conductors and Cables.”

C. Verify tightness and torque all accessible bolted electrical connections to manufacturer’s specified values using a calibrated torque wrench. Provide a list of all torqued connections and values.

D. Provide all communications wiring between remote metering and communication modules and the University’s SCADA system. Verify that each circuit breaker’s address for microprocessor-communication packages corresponds to SCADA network requirements.

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 26 Section “Identification for Electrical Systems.”

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

D. Arc Flash Labels: provide as specified in Division 26 Section "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.
3. Submit to NU Chief Electrician.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:
   a. Initial Infrared Scanning: After Substantial Completion, but not more than 90 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front and rear panels so joints and connections are accessible to portable scanner.
   b. Instruments and Equipment:
      1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   c. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear line-up 11 months after date of Substantial Completion.
4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
5. Submit reports to NU Electric Shop.

D. Switchboard will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection report, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.
3.6 CLEANING  
A. Vacuum dirt and debris from switchboard compartments; do not use compressed air to assist in cleaning.

3.7 ADJUSTING  
A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
B. Set field-adjustable circuit-breaker trip ranges as specified in the “Overcurrent Protective Device Coordination Study.” Provide list of “as left” settings and submit to Electric Shop.

3.8 TRAINING  
A. Engage a factory-authorized service representative to train the University's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units. Provide eight (8) hours of classroom and hands-on training.

END OF SECTION 26 2413
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Distribution panelboards.
   2. Lighting and appliance branch-circuit panelboards.
   3. Electronic-grade panelboards.

B. Related Sections include the following:
   1. Division 26 Section “Surge Protective Devices for Low-Voltage Electrical Power Circuits” for transient voltage surge suppressors for low-voltage power, control, and communication equipment located in Panelboards.

1.3 DEFINITIONS

A. SVR: Suppressed voltage rating.

B. SPD: Surge Protective Device.

1.4 (future use)

1.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of panelboard, switching and overcurrent protective device, surge suppression device, accessory, and component indicated. Include dimensions and manufacturers’ technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.
   1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
   2. Detail enclosure types and details for types other than NEMA 250, Type 1.
   3. Detail bus configuration, current, and voltage ratings.
   4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
6. Include wiring diagrams for power, signal, and control wiring.
7. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.

1.6 INFORMATIONAL SUBMITTALS
A. Field Quality-Control Reports:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
B. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

1.7 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
   2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.
   3. Circuit directories with load descriptions prepared in electronic format. Submit to Electric Shop.

1.8 MAINTENANCE MATERIAL SUBMITTALS
A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Keys: Two spares for each type of panelboard cabinet lock. Keys shall be received and signed for by the University's Chief Electrician. Failure to do so will result in Contractor re-keying all equipment at no cost to NU.

1.9 QUALITY ASSURANCE
A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
D. Comply with NEMA PB 1.

E. Comply with NFPA 70.

F. Comply with most current edition of the Northwestern University Design Standards.

G. Series rated equipment shall not be used.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards.

B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.11 PROJECT CONDITIONS

A. Environmental Limitations:

   1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet
      work in spaces is complete and dry, work above panelboards is complete, and temporary
      HVAC system is operating and maintaining ambient temperature and humidity conditions
      at occupancy levels during the remainder of the construction period.

   2. Rate equipment for continuous operation under the following conditions unless otherwise
      indicated:

      a. Ambient Temperature: Not exceeding minus 22 deg F (minus 30 deg C) to plus
         104 deg F (plus 40 deg C).

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

   1. Ambient temperatures within limits specified.
   2. Altitude not exceeding 6600 feet (2000 m).

C. **(Delete This Paragraph If Not Required)** [Interruption of Existing Electric Service: Do
   not interrupt electric service to facilities occupied by Northwestern University or others
   unless permitted under the following conditions and then only after arranging to provide
   temporary electric service according to requirements indicated:

   1. Notify Northwestern University Electric Shop no fewer than [two] calendar weeks
      in advance of proposed interruption of electric service.
   2. Indicate method of providing temporary utilities.
   3. Do not proceed with interruption of electrical service without the University’s Chief
      Electrician’s written permission.
   4. Northwestern University Lock-out/Tag-out procedures shall be used with
      Contractor controlled locks and tags.
   5. Comply with NFPA 70E.]

1.12 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that
penetrates walls or is supported by them, including electrical and other types of equipment,
raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces.
Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.13 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: **Five** years from date of Beneficial Occupancy.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Subject to compliance with requirements, provide products by Gus Berthold Electric with components by one of the following:

1. Siemens Industry Inc.
2. Eaton Corp. Electrical Group.

B. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

C. Enclosures: Flush and surface-mounted cabinets.

1. Rated for environmental conditions at installed location.

   a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
   b. Outdoor Locations: NEMA 250, Type 3R.
   d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
   e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.


3. Flush type latch and lock assembly shall be provided.

4. All keying and locks for cabinets shall be alike and comply with University Standards.

5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.

6. Finishes:

   a. Panels and Trim: 12 gauge hot rolled steel formed and welded steel, factory finished immediately after cleaning and pre-treating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
b. Back Boxes: 12 gauge steel.
c. Panelboard boxes shall be supplied without knock-outs (blank end walls).


D. Incoming Mains Location: Top.

E. Phase, Neutral, and Ground Buses:
   3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
   4. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
   5. Fully rated Neutral bus.
   6. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.

F. Conductor Connectors: Suitable for use with conductor material and sizes.
   2. Main and Neutral Lugs: Mechanical type.
   3. Ground Lugs and Bus-Configured Terminators: Mechanical type.
   4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
   5. Sub-feed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
   6. Gutter-Tap Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
   7. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

G. Service Equipment Label: NRTL labeled for use as service equipment for panelboards with one or more main service disconnecting and overcurrent protective devices.

H. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

I. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals, minimum 22 kAIC.

2.2 DISTRIBUTION PANELBOARDS

A. Panelboards: NEMA PB 1, power and feeder distribution type.

B. Doors: Secured with vault-type latch with tumbler lock; keyed alike per University’s Master key protocol, use Corbin #4T3142 unless directed in writing otherwise.
   1. For doors more than 36 inches (914 mm) high, provide two latches, keyed alike.
C. Mains: Circuit breaker or Lugs as shown on One Line Diagram.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers.

### 2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

B. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

C. [Contactors in Main Bus: NEMA ICS 2, Class A, electrically held, general-purpose controller, with same short-circuits interrupting rating as panelboard.]

1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.

D. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike per University's Master Key protocol, use Corbin #4T3142 unless directed in writing otherwise.

### 2.4 ELECTRONIC-GRADE PANELBOARDS

A. Panelboards: NEMA PB 1; with factory-installed, integral TVSS; labeled by an NRTL for compliance with UL 67 after installing TVSS.

B. Doors: Secured with vault-type latch with tumbler lock; keyed alike per University’s Master key protocol, use Corbin #4T3142 unless directed in writing otherwise.

C. Main Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.

D. Branch Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.

E. Buses:

1. Copper phase and neutral buses; 200 percent capacity neutral bus and lugs.
2. Copper equipment and isolated ground buses.


### 2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Subject to compliance with requirements, provide products by one of the following:

1. Siemens Industry Inc.
2. Eaton Corp. Electrical Group.

B. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.
C. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, fully rated, with interrupting capacity to meet available fault currents. Series rated equipment is not acceptable.

1. Circuit-breaker frame sizes 250 A and larger shall be 100% rated to continuously carry their full ampere capacity.
2. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes up to 250 A.
4. Electronic trip circuit breakers with RMS sensing; field-replaceable rating plug or field-replaceable electronic trip for circuit-breaker frame sizes 250 A and larger; and the following field-adjustable settings:
   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long- and short-time time adjustments.
   d. Ground-fault pickup level, time delay, and I²t response.
5. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
7. Arc-Flash Circuit Interrupters (AFCI): Single (15 – 20A) or two pole (15 – 20A) configuration. LED trip indicator. UL 1669 listed.
8. Multi-pole circuit breakers shall have common trip, use of handle ties is not permitted.
9. Standard frame sizes, trip ratings, and number of poles.
10. Application Listing: Appropriate for application. (e.g. HACR, SWD)
11. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
12. Molded-Case Circuit-Breaker (MCCB) Features and Accessories: (Edit For Project Requirements)
   a. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   b. Communication Capability: Communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
   c. Shunt Trip: 120 -V trip coil energized from separate circuit.
   d. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
   e. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
   f. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
   g. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
   h. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
   i. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handles in on or off position.
   j. Handle Clamp: Loose attachment, for holding circuit-breaker handles in on position.
2.6 PANELBOARD SUPPRESSORS
   A. Subject to compliance with requirements, Surge Protection Devices shall be IEEE C62.41-
      compliant, externally mounted, and complying with UL 1449, 3rd edition and Specification 26
      4313.

2.7 RETRO-FIT PANELBOARD KITS
   A. The panelboard kit shall be specifically designed for retrofit applications in existing panelboard
      boxes. Trims for retrofit panelboards shall be designed specifically for retrofit applications. Trim
      mounting shall not be dependent nor attached to the existing enclosure. The trim and door shall
      attach directly to the panelboard dead-front assembly so that no external trim-fastening
      hardware shall be required. Panelboards shall be fully rated.
   B. Interiors shall have field adjustable height and depth.
   C. Factory installed copper neutral and ground bars, field bondable for Service Entrance
      applications.
   D. Bolt-on type, heavy-duty, quick-make, quick-break, single- and multi-pole circuit breakers of the
      types specified herein, shall be provided for each circuit.
   E. Existing enclosures shall be identified for retrofit suitability in advance. Enclosure size
      calculations shall be submitted to NU Electric Shop. The structural integrity of all existing
      enclosures shall be verified. Any enclosure that is damaged shall be replaced with a new
      enclosure and panelboard.

2.8 ACCESSORY COMPONENTS AND FEATURES
   A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective
      device test, inspection, maintenance, and operation.
   B. Portable Test Set: For testing functions of solid-state trip devices without removing from
      panelboard. Include relay and meter test plugs suitable for testing panelboard meters and
      switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.
   B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or
      have been exposed to water.
   C. Examine elements and surfaces to receive panelboards for compliance with installation
      tolerances and other conditions affecting performance of the Work.
   D. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Wall Mounted Panelboards: Do not attach directly to walls or structural surfaces. Attach panelboard to the vertical finished or structural surface behind the panelboard on channels such as “Unistrut”.

C. Floor Mounted Panelboards: Install panelboards on 4 inch high (Evanston: 6 inch high east of Sheridan Rd.) concrete bases. Comply with requirements for concrete base specified in Division 03 Sections.
   1. For panelboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   2. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   3. Install anchor bolts to elevations required for proper attachment to panelboards with not more than 1” exposed.

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

E. Mount top of trim 90 inches (2286 mm) above finished floor unless otherwise indicated.

F. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

G. Install overcurrent protective devices and controllers not already factory installed.

H. Provide GFI circuit breakers with 30 mA sensitivity trip for all freeze protection, temperature maintenance, and heat tracing circuits.

I. Install filler plates in unused spaces.

J. Punch out openings only in those areas perforated by the manufacturer in the top and bottom end panels, field punched openings not permitted.

K. Circuit breaker handle locks shall be provided for all circuits that supply exit signs, emergency lights, energy management and control system panels and fire alarm panels.

L. Flush mounted panelboards: Stub fourteen 3/4-inch empty conduits from panelboard into an 18” x 18” pull box located in accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

M. Arrange conductors in gutters into groups and bundle and wrap in order of H-N-G with wire ties after completing load balancing.

N. Comply with NECA 1.

O. New circuit breakers installed in existing panelboards shall be of standard manufacture, shall match existing, and shall have an interrupting rating of not less than the lowest rated circuit breaker in the panelboard.
3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."

B. Circuit breakers serving Fire Alarm panels shall have a factory or field applied Red finish, the circuit shall be highlighted on the circuit directory.

C. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Northwestern University's final room designations. Obtain approval before installing. Use a computer to create directory; handwritten directories are not acceptable.

D. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

E. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

F. Arc Flash Labels: provide as specified in Division 26 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.
3. Comply with NETS.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, an infrared scan of each panelboard shall be performed by a third party. Remove front so joints and connections are accessible to portable scanner.

1. Instrument: Use an infrared-scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
2. Record of Infrared Scanning: Prepare a certified report that identifies panelboards checked and that describes infrared-scanning results. Include notation of deficiencies detected, remedial actions taken, and observations after remedial action.
3. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.

D. Panelboards will be considered defective if they do not pass tests and inspections.
E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

F. No panelboard shall be energized unless test reports have been reviewed and accepted by NU Electric Shop.

3.5 CLEANING

A. Vacuum dirt and debris from panelboard tubs; do not use compressed air to assist in cleaning.

3.6 ADJUSTING

A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in the “Overcurrent Protective Device Coordination Study.” Provide list of “as left” settings and submit to Electric Shop.

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.

1. Measure as directed during period of normal system loading.
2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records to NU Electric Shop.
4. Tolerance: Difference exceeding 15 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.7 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 26 2416
PART 1 - GENERAL

1.1 SUMMARY

A. Section includes equipment for metering of the electrical power system.

B. Related Sections:
   1. Section 26 2300 for metering installed in Low Voltage Switchgear.
   2. Section 26 2413 for metering installed in Switchboards.
   3. Section 26 3600 for metering installed in Transfer Switches.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.
   1. Attach copies of approved Product Data submittals for products (such as switchboards and switchgear) that describe power metering features to illustrate coordination among related equipment and power metering.

B. Shop Drawings: For power metering equipment. Include plans, elevations, sections, details, and attachments to other work.
   1. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components.
   2. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Other Informational Submittals: System installation and setup guides, with data forms to plan and record options and setup decisions.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data:
   1. Operating and applications software documentation.
   2. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy submittal.
B. Software and Firmware Operational Documentation:
   1. Software operating and upgrade manuals.
   2. Software Backup: On a magnetic media or compact disc, complete with Owner-selected options.

C. Software Upgrade Kit: For Owner to use in modifying software to suit future power system revisions or power metering revisions.

D. Software upgrades required by and installed for operating and programming digital and analog devices.

1.5 QUALITY ASSURANCE
A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with most current edition of the Northwestern University Design Standards.

1.6 WARRANTY
A. The meter shall have a Manufacturer’s standard 4-year warranty.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Electro Industries/Gauge Tech “Nexus 1500” (mains on unit substations and switchboards).
   2. Electro Industries/Gauge Tech “Shark 200 V-5” (feeders).

2.2 FUNCTIONAL DESCRIPTION
A. Metering Devices: Monitor and record load profiles and chart energy consumption patterns.
   1. Measure and Record Metering Data for the Following:
      a. Electricity.

B. The meter shall be designed for Multifunction Electrical Measurement on 3 phase power systems. The meter shall perform to spec in harsh electrical applications in high and low voltage power systems.
   1. The meter shall support 3-Element Wye, 2.5 Element Wye, 2 Element Delta, 4 wire Delta systems.
   2. The meter shall accept universal voltage input.
   3. The meter’s surge withstand shall conform to IEEE C37.90.1 and ANSI C62.41.
   4. The meter shall be user programmable for voltage range to any PT ratio.
5. The meter shall accept a burden up to 0.36VA per phase, Max at 600V, and 0.014VA at 120 Volts.
6. The meter shall accept a voltage input range of up to 576 Volts Line to Neutral, and up to 721 Volts Line to Line.
7. The meter shall accept a current reading of up to 11 Amps continuous.
8. The meter shall have color-coordinated voltage and current inputs.
9. The meter shall have a phasor diagram that clearly shows wiring status.

C. The meter shall use a dual input method for current inputs. Method one shall allow the CT to pass directly through the meter without any physical termination on the meter, ensuring the meter cannot be a point of failure on the CT circuit. The second method shall provide additional termination pass-through bars, allowing the CT lead to be terminated on the meter. The meter must support both termination methods.

1. Fault Current Withstand shall be 100 Amps for 10 seconds, 300 Amps for 3 seconds, and 500 Amps for 1 second.
2. The meter shall be programmable for current to any CT ratio. DIP switches or other fixed ratios shall not be acceptable.
3. The meter shall accept a burden of 0.005VA per phase, Max at 11 Amps.
4. The meter shall begin reading at 5mA pickup current.
5. Pass through wire gauge dimension of 0.177" / 4.5 mm shall be available.
6. All inputs and outputs shall be galvanically isolated to 2500 Volts AC.
7. The meter shall accept current inputs of class 10: (0 to 10) A, 5 Amp Nominal, and class 2 (0 to 2) A, 1A Nominal Secondary.

D. The meter shall have an accuracy of +/- 0.1% or better for Volts and Amps, and 0.2% for power and energy functions. The meter shall meet the accuracy requirements of IEC62053-22 (Class 0.2%) and ANSI C12.20 (Class 0.2%). The meter shall have a Frequency measurement accuracy of not less than 0.001 Hz.

1. The meter shall provide true RMS measurements of voltage, - phase to neutral and phase-to-phase; and current, per phase and neutral.
2. The meter shall calculate RMS readings, sampling at over 400 samples per cycle on all channels measured readings continuously with no cycle blind spots.
3. The meter shall utilize 24 bit Analog to Digital conversion.
4. The meter shall provide %THD (% of Total Harmonic Distortion). Harmonic magnitude recording to the 40th order shall be available for voltage and current harmonics.

E. The meter shall provide a simultaneous voltage and current waveform recorder.

1. The meter shall be capable of recording 512 samples per cycle for voltage sag or swell or a current fault event.
2. The meter shall provide pre- and post-event recording capability.
3. The meter shall have a programmable sampling rate for the waveform recorder.
4. The meter shall have an advanced DSP design that allows power quality triggers to be based on a 1 cycle updated RMS.
5. The meter shall allow up to 170 events to be recorded.
6. The meter shall store waveform data in a first-in, first-out circular buffer to insure that data is always being recorded.

F. The meter shall include a three-line, bright red, .56” LED display.

1. The meter shall fit in both DIN 92mm and ANSI C39.1 round cut-outs.
2. The meter must display a % of Load Bar on the front panel to provide an analog feel. The % Load bar shall have not less than 10 segments.

G. The meter shall be available in transducer only version, with no display.

1. The meter shall mount directly to a DIN rail and provide RS485 Modbus or DNP 3.0 output.

H. The meter shall be a traceable revenue meter, which shall contain a utility grade test pulse allowing power providers to verify and confirm that the meter is performing to its rated accuracy.

I. Power meter shall include virtual measurement upgrade packs, which shall allow user to upgrade in field without removing installed meter.

1. The six Virtual Upgrade packs shall be:
   a. Volts, Amps, kW, kVAR, PF, kVA, Freq., kWh, kVAh, kVARh, and I/O Expansion - V1
   b. Above with 2 Megabytes of memory for Data-logging - V2
   c. Above with Power Quality Harmonics - V3
   d. Above, with Limit and Control Functions - V4
   e. Above, with 64 samples per cycle Waveform Recorder and 3 Megabytes of memory for Data-logging - V5
   f. Above, with 512 samples per cycle Waveform Recorder and 4 Megabytes of memory for Data-logging - V6

2. These Virtual Upgrade packs must be able to be implemented without physically removing the installed meter.

J. The meter shall include 2 independent communications ports on the back and face plate, with advanced features.

1. One port shall provide RS485 communication speaking Modbus ASCII, Modbus RTU, or DNP 3.0 protocol through back plate.
2. Baud rates shall be from 1200 baud to 57600 baud for the RS485 port.
3. The meter shall provide an optical IrDA port (through faceplate), as the second communication port, which shall allow the unit to be set up and programmed using a remote laptop without need for a communication cable.
4. The meter shall have an Ethernet connection card and support Modbus TCP or DNP TCP protocols.
5. The meter shall have Pocket PC based software available for remote programming and integration.

K. The meter shall provide user configured fixed window or rolling window demand. This shall allow the user to set up the particular utility demand profile.

1. Readings for kW, kVAR, kVA and PF shall be calculated using utility demand features.
2. All other parameters shall offer max and min capability over the user selectable averaging period.
3. Voltage shall provide an instantaneous max and min reading displaying the highest surge and lowest sag seen by the meter.
4. The meter shall provide an update rate of every 6 cycles for Watts, VAR and VA. All other parameters shall be every 60 cycles.
L. The meter shall support a power supply of 90 to 265 Volts AC and 100 to 370 Volts DC. Universal AC/DC Supply shall be available and shall have a burden of less than 11VA. An optional power supply of 18-60 Volts DC shall be available.

M. The meter shall provide Limits Alarms and Control Capability as follows:

1. Limits can be set for any measured parameter.
2. Up to 16 limits can be set.
3. Limits shall be based on % of Full Scale settings.
4. Manual Relay Control shall be available through software.
5. Relay set delays and reset delays shall be available.
6. Relay control shall be available through DNP over Ethernet with the Ethernet Option card.

N. The meter shall have data-logging capability with the 2, 3, and 4 Megabyte memory upgrade (Virtual Upgrade packs 2-6). The meter shall have a real-time clock that allows for time stamping of all the data in the meter when log events are created. The meter with Virtual Upgrade packs 2-4 shall have six logs; the meter with Virtual Upgrade packs 5 and 6 shall also have the Waveform Log:

1. The meter shall have three historical logs for trending profiles. Each log shall be capable of being programmed with up to 64 parameters. The user shall have the ability to allocate memory between the three historical logs in order to increase or decrease the memory allotted to each of the logs.
2. The meter shall have a log for Limits Alarms. The Limits log shall provide magnitude and duration of an event, time-stamp, and log value. The log must be capable of recording to 2048 events.
3. The meter shall have a log for System Events. The System Events log shall record the following occurrences with a time-stamp: Demand Resets, Password Requests, System Startup, Energy Resets, Log Resets, Log Reads, and Programmable Settings Changes.
4. The meter shall have a log for I/O changes. The I/O Change log shall provide a time-stamped record of any Relay Outputs and any Input Status changes. The log must be capable of recording up to 2048 events.
5. The meter with Virtual Upgrade packs 5 and 6 shall have a log which is capable of recording a waveform both when a user-programmed value goes out of limit and when the value returns to within limit.

O. The meter shall have I/O expandability through two Option card slots on the back.

1. The cards shall be capable of being installed in the field, without removing the meter from installation.
2. The meter shall auto-detect the presence of any I/O Option cards.
3. The Option card slots shall accept I/O cards in all of the following formats: 100BaseT Ethernet Communication Card; Four Channel Bi-directional 0-1mA Output Card; Four Channel 4-20mA Output Card; Two Relay Outputs/2 Status Inputs Card; Four Pulse Output/4 Status Inputs Card; Fiber Optic Card; IEC 61850 Protocol Ethernet Network Card.
4. The meter shall be capable of accepting any combination of up to two cards.
   a. When two Ethernet cards are installed in the meter, an independent IP address and MAC address shall be assignable to each card.
5. The Ethernet Option Card shall provide the meter with 100BaseT Ethernet functionality. The Ethernet Option card shall:
a. Allow the meter to speak with 12 simultaneous sockets of Modbus TCP, so that multiple requests for data can be received simultaneously.
b. Allow the meter to speak with 5 simultaneous sockets of DNP over TCP/IP so that multiple requests can be handled simultaneously.
c. Allow the meter to speak with both Modbus TCP and DNP over Ethernet simultaneously.
d. Process data at not more 0.6 KBs to 1.5 KBs.
e. Allow auto transmit/receive detection for straight or null RJ45 cables.
f. Provide an embedded Web server that allows access to metered readings through the Internet, using any standard Web browser from a PC, smart phone, or tablet PC.

6. The 1mA Option Card shall provide the following features:
   a. 4 channel, bi-directional 0-1mA outputs.
   b. Assignable to any measured parameter.
   c. 0.1% of Full Scale accuracy throughout range and load.
   d. Maximum load impedance to 10k Ohms, with no accuracy losses.

7. The 20mA Option Card shall provide the following features:
   a. 4 channel, 4-20mA outputs.
   b. Assignable to any measured parameter.
   c. 0.1% of Full Scale accuracy throughout range and load.
   d. Maximum load impedance to 850 Ohms, with no accuracy losses.
   e. Loop powered using up to 24 Volts DC.

8. The Relay Output/Status Input Option Card shall provide the following features:
   a. 2 Relay outputs, 2 Status inputs.
   b. Status Inputs – Wet/Dry Auto Detect up to 150 Volts DC.
   c. Trigger on User Set Limits/Alarms (with Virtual Upgrade pack 4).
   d. Set delays and Reset delays.

9. The Pulse Output/Digital Input Option Card shall provide the following features:
   a. 4 KYZ pulse/4 Status inputs.
   b. Programmable to any energy parameter and pulse value.
   c. Programmable to End of Interval pulse.
   d. Can function for manual relay control and limit based control (with Virtual Upgrade pack 4).
   e. 120mA continuous load current.
   f. DNP input.

10. The Fiber Optic Option Card shall provide the following features:
    a. Built in logic to mimic RS485 half-duplex bus, allowing the user to daisy chain meters for low installation cost.
    b. ST Terminated Option.
    c. Versatile Link Terminated Option.
    d. Modbus and DNP 3.0 protocols available.

11. The IEC 61850 Protocol Ethernet Network Option Card shall provide the following features:
a. Integrates into any IEC 61850 network.
b. Provides support for Modbus and IEC 61850 protocols simultaneously.
c. Configurable for multiple logical nodes.
d. Provides buffered and un-buffered reporting.
e. Provides dual Ethernet IEC 61850 Protocol Network option cards.
f. Is certified by a 3rd party Authorized IEC61850 Test Laboratory.
g. Is capable of supporting two Ethernet /IP connections with separate /IP address, each running IEC 61850 protocol.

P. The meter shall have transformer loss, line loss, and total substation loss compensation.

1. Substation losses shall be programmable for Watts and VARs, and for Ferris and Copper losses.
2. The meter shall have CT and PT compensation to set compensation factors for errors in CTs and PTs connected to the meter.

Q. The following options shall be available for ordering:
2.3 SYSTEM REQUIREMENTS

A. Surge Protection: For external wiring of each conductor entry connection to components to protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads.
B. Provide fuses on each of the sense voltages and on the control power, use Electro Industries EI-CP Panel meter protective fuse kit.

### 2.4 POWER METERS

A. Separately mounted, permanently installed instrument for power metering, complying with UL 1244.

1. Enclosure and faceplate: NEMA 250, Type 12.

B. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Indoor installation in spaces that have environmental controls to maintain ambient conditions of (-20 to +70) degrees C.

### 2.5 LOW-VOLTAGE WIRING

A. Comply with University Standards for RS-485 cabling.

B. Comply with Section 26 0519 "Low - Voltage Electrical Power Conductors and Cables."

### PART 3 - EXECUTION

#### 3.1 CABLING

A. Comply with NECA 1, current edition.

B. Provide all communications wiring between remote metering communication modules and the University’s SCADA network.

C. Wiring Method: Install wiring in raceway except within Switchgear, Switchboards and the like. Conceal raceway and wiring except in unfinished spaces.

#### 3.2 IDENTIFICATION

A. Identify components and power and control wiring according to Section 26 0553 "Identification for Electrical Systems."

B. Label each power metering module with a unique designation.

#### 3.3 GROUNDING

A. Comply with IEEE 1100, "Recommended Practice for Powering and Grounding Electronic Equipment."
3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.
   1. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:
   1. Electrical Tests: Use caution when testing devices containing solid-state components.
   2. Continuity tests of circuits.
   3. Coordinate testing required by this Section with that required by Sections specifying equipment being metered.
      a. Metering Test: Load feeders, measure loads on feeder conductor with an rms reading clamp-on ammeter, and simultaneously read indicated current on the same phase at central-processing workstation. Record and compare values measured at the two locations. Resolve discrepancies greater than 5 percent and record resolution method and results.

C. Correct deficiencies, make necessary adjustments, and retest. Verify that specified requirements are met.

D. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.

E. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

F. Remove and replace malfunctioning devices and circuits and retest as specified above.

3.5 DEMONSTRATION

A. Train the University’s maintenance personnel to adjust, operate, and maintain systems. See Division 1 Sections.
   1. Train University’s management and maintenance personnel in interpreting and using metering displays and in configuring reports. Include troubleshooting, servicing, adjusting, and maintaining equipment. Provide a minimum of 12 hours’ training.

END OF SECTION 26 2713
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. University IT/IS Standards for Telecommunications devices.

1.2 SUMMARY

A. Section Includes:
   1. Receptacles, general purpose.
   2. Receptacles with integral GFCI.
   3. USB Charger receptacles.
   4. AFCI receptacles.
   5. Twist-locking receptacles.
   6. Isolated-ground receptacles.
   7. Tamper-resistant receptacles.
   8. Weather-resistant receptacles.
  10. Cord and plug sets.
  11. Wall box dimmers.
  12. Wall box dimmer/sensors.
  13. Wall box occupancy/vacancy sensors.
  15. Floor service outlets.

1.3 DEFINITIONS

A. AFCI: Arc Flash Circuit Interrupter.

B. EMI: Electromagnetic interference.

C. GFCI: Ground-Fault Circuit Interrupter.

D. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

E. RFI: Radio-frequency interference.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
1. Receptacles for University-Furnished Equipment: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by UL and marked for intended location and application.

B. Comply with NFPA 70.

C. Comply with most current edition of the Northwestern University Design Standards.

D. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

1.6 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for pre-marking wall plates.

C. Samples: One for each type of device and wall plate listed below, in each color specified.

1. List of devices for which samples are desired.

1.7 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.8 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers’ packing-label warnings and instruction manuals that include labeling conditions.

B. Plan drawing(s) in AutoCAD format mapping all locations of all GFCI and AFCI receptacles and submitted on CD-ROM.

1.9 WARRANTY

A. Special Warranty: Manufacturer’s standard form in which manufacturer agrees to repair or replace devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period:
   a. Two years from date of Beneficial Occupancy: GFCI, AFCI devices
   b. Five years from date of Beneficial Occupancy:
   c. Ten years from date of Beneficial Occupancy: Receptacles
2.1 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: UL listed and labeled as defined in NFPA 70 and marked for intended location and application.

B. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranded building wire.
2. Devices shall comply with the requirements in this Section.

2.2 STRAIGHT-BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Heavy duty specification grade complying with NEMA WD 1, NEMA WD 6 Configuration 5-20R, and UL 498.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Hubbell; HBL5351 (single), HBL5352 (duplex).
   b. Pass & Seymour; 5361 (single), 5362 (duplex).
   c. Leviton; 5351 (single), 5352 (duplex)

B. Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, and UL 498.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Hubbell; IG5362.
   b. Pass & Seymour; IG5362.
   c. Leviton; 5362-IG

2. Description: Straight blade; equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

C. USB Charger Type Duplex Convenience Receptacles:

1. Specialized Receptacles: Comply with NEMA WD 1, NEMA WD 6 for standard configurations and UL 498. Comply with USB battery charging spec USB BC1.2.

2. Products: Subject to compliance with requirements, provide one of the following:
   a. Hubbell; USB20X2.
   b. Pass & Seymour; TR5362USB.
   c. Leviton; T5832.

3. Description:
   a. Straight blade, 125 V, 20 A; NEMA 5-20R.
   b. Non-feed through type.
   c. Solid state charger device with duplex receptacle.
d. Dual USB charging ports 3.0 A (min.), 5 VDC dual USB charging ports.
e. Compatible with USB 2.0 devices.
f. Tamper resistant.

d. Dual USB charging ports 3.0 A (min.), 5 VDC dual USB charging ports.
e. Compatible with USB 2.0 devices.
f. Tamper resistant.

D. Tamper-Resistant, Duplex, Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, ANSI C-73, and UL 498.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Hubbell CR20 - TR
   b. Leviton; TCR – 20.
   c. Pass & Seymour; TR5362

2. Description:
   a. Built-in UL Listed, mechanical safety shutter mechanism prevents access to contacts unless a two-pronged plug is inserted to ensure that foreign objects are locked out.
   b. “TR” mold mark designation provides visual identification when installed.
   c. Self grounding clip for automatic grounding in grounded metal box.

2.3 GFCI RECEPTACLES

A. General Description:

1. Straight blade, non-feed through type.
2. Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and UL 943, Class A.
3. Include trip/reset buttons.
4. Include correct wiring/trip indicator LED light.

B. Tamper-Resistant GFCI, Duplex Convenience Receptacles, 125 V, 20 A:

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Hubbell; GFTR20.
   b. Pass & Seymour; 2095TR.
   c. Leviton; GFTN2

2.4 AFCI RECEPTACLES

A. General Description:

1. Straight blade, feed through type.
2. Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and UL 1699.A.
3. Include trip/reset buttons.
4. Include correct wiring/trip indicator LED light.

B. Tamper-Resistant AFCI, Duplex Convenience Receptacles, 125 V, 20 A:

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Hubbell; AFR20TR.
b. Pass & Seymour; AF20TR.
c. Leviton; AFTR2

2.5  
(future use)

A.

2.6  RECEPTACLES FOR SPECIAL EQUIPMENT

A. Specialized Receptacles: Comply with NEMA WD 1, NEMA WD 6 for standard configurations and UL 498.

B. Products: Subject to compliance with requirements, provide one of the following:

1. Hubbell.
2. Pass & Seymour.
3. Leviton.

2.7  HAZARDOUS (CLASSIFIED) LOCATION RECEPTACLES

A. Wiring Devices for Hazardous (Classified) Locations: Comply with NEMA FB 11 and UL 1010.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Crouse-Hinds.
   b. EGS/Appleton Electric.
   c. Killark; Division of Hubbell Inc.

2.8  TWIST-LOCKING RECEPTACLES

A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6, Configuration L5-20R, and UL 498.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Hubbell; HBL2310.
   b. Pass & Seymour; L520-R.
   c. Leviton; 2310

B. Isolated-Ground, Single Convenience Receptacles, 125 V, 20 A:

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Hubbell; IG2310.
   b. Pass & Seymour; IG4700.
   c. Leviton; 2310-IG.

2. Description:

   a. Comply with NEMA WD 1, NEMA WD 6, Configuration L5-20R, and UL 498.
2.9 PENDANT CORD-CONNECTOR DEVICES

A. Description:
   1. Matching, locking-type plug and receptacle body connector.
   2. NEMA WD 6 Configurations L5-20P and L5-20R, heavy-duty grade, and FS W-C-596.
   4. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.10 CORD AND PLUG SETS

A. Description:
   1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
   2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.

2.11 WALL-BOX DIMMERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Lutron Electronics.

B. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters, compatible with 1% LED dimming-drivers.

C. Control: Continuously adjustable slide-to-off with single-pole or three-way switching. Comply with UL 1472.

D. LED Dimmer Switches: Modular; compatible with 1% LED dimming-drivers.
   1. Zero to 10 VDC for direct control of 3rd party LED drivers without use of separate power pack.

E. Finish: Color to be coordinated with the Architect from Manufacturer’s standard colors.

2.12 WALL-BOX DIMMERS/SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. Lutron Electronics.

B. LED Dimmer Switches:  Modular; 0 – 10 VDC Dimmer/Sensor compatible with 3rd party LED drivers; dimmer-driver combination capable of consistent dimming with low end not greater than 1% of full brightness, with integral, quiet, continuously adjustable slide-to-off with single-pole or three-way switching. Comply with UL 1472

1. Operating Environment: Operating temperature 32-104 degrees F with a relative humidity (non-condensing) of 0% to 95%.

C. Occupancy Switches:

1. Description: Line Voltage type, 120/230/277 VAC, adjustable time delay 1, 5, 15, or 30 minutes, 180-degree field of view, UL Listed.
2. Sensor: Passive infrared (PIR) with ambient light detection learning mode with a minimum PIR coverage area of 30 ft. x 30 ft.
3. Operating Environment: Operating temperature 32-104 degrees F with a relative humidity (non-condensing) of 0% to 95%.

D. Finish: Color to be coordinated with the Architect from Manufacturer’s standard colors.

E. Warranty: 5 Years.

2.13 WALL BOX OCCUPANCY/VACANCY SENSORS

A. Line voltage PIR technology wall-switch sensors

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Lutron Electronics.

2. Description: Line Voltage PIR Technology type, 120/230/277 VAC, adjustable time delay 1, 5, 15, or 30 minutes, 180-degree field of view, UL Listed with a minimum PIR coverage area of 30 ft. x 30 ft.
3. Programmable as a Vacancy (manual ON/auto OFF) or Occupancy sensor (auto ON/auto OFF).
4. Operating Environment: Operating temperature 32-104 degrees F with a relative humidity (non-condensing) of 0% to 95%.

B. Finish: Color to be coordinated with the Architect from Manufacturer’s standard colors.

C. Warranty: 5 Years.

2.14 (Future use)

2.15 TOGGLE SWITCHES

A. Comply with NEMA WD 1, UL 20, and FS W-S-896.

B. Switches, 120/277 V, 20 A:
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Single Pole:
      1) Hubbell; HBL1221.
      2) Pass & Seymour; CSB20AC1.
      3) Leviton; 1221
   b. Two Pole:
      1) Hubbell; HBL1222.
      2) Pass & Seymour; CSB20AC2.
      3) Leviton; 1222
   c. Three Way:
      1) Hubbell; HBL1223.
      2) Pass & Seymour; CSB20AC3.
      3) Leviton; 1223
   d. Four Way:
      1) Hubbell; HBL1224.
      2) Pass & Seymour; CSB20AC4.
      3) Leviton; 1224

C. Pilot-Light Switches, 20 A:
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Hubbell; HBL1201PL for 120 and 277 V.
      b. Pass & Seymour; PS20AC1RPL for 120 V, PS20AC1RPL7 for 277 V.
      c. Leviton; 1201-PL
   2. Description: Single pole, with neon-lighted handle, illuminated when switch is "off."

D. Key-Operated Switches, 120/277 V, 20 A:
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Hubbell; HBL1221L.
      b. Pass & Seymour; PS20AC1-L.
      c. Leviton; 1221-2L
   2. Description: Single pole, with factory-supplied key in lieu of switch handle. Provide six (6) spare keys.

2.16 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.
   1. Plate-Securing Screws: Metal with head color to match plate finish.
   2. Material for Finished Spaces:
a. Shall be same manufacturer as device
b. Offices and administrative areas: Painted steel, color selected by Architect from specified selections.
c. Laboratories, kitchens, food preparation: 0.035-inch- (1-mm-) thick, satin-finished, Type 302 stainless steel.

4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.
5. Receptacles dedicated for use with computers: Use engraved white plastic, self adhesive label with 0.188” high black-filled lettering on face of plate to read “COMPUTER ONLY”.

B. Wet-Location, Weatherproof-in-use Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

2.17 FLOOR SERVICE FITTINGS

A. Coordinate fittings with floor boxes as described in Section 26 0533.
B. Type: Modular, flush-type, dual-service units suitable for wiring method used.
C. Compartments: Barrier separates power from voice and data communication cabling.
D. Service Plate: Rectangular die-cast aluminum with satin finish.
E. Power Receptacle: NEMA WD 6 Configuration 5-20R, unless otherwise indicated.
F. Voice and Data Communication Outlet: Comply with University IT/IS Department Standards.

2.18 FINISHES

A. Device Color:
   1. Wiring Devices Connected to Normal Power System: Ivory, White, Blue, Gray, and Brown as selected by Architect or required by NFPA 70 or device listing.
   2. Dedicated outlets: Grey.
   4. Isolated-Ground Receptacles: Ivory with Orange triangle.
   5. UPS: Blue.
   7. Temporary devices: Black.

B. Wall Plate Color: Match device color.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.
B. Coordination with Other Trades:
   1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
   2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
   3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
   4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:
   1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
   2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking or cutting strands from stranded wire.
   3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
   4. Existing Conductors:
      a. Cut back and pigtail, or replace all damaged conductors.
      b. Straighten conductors that remain and remove corrosion and foreign matter.
      c. Pig-tailing existing conductors are permitted, provided the outlet box is large enough.

D. Device Installation:
   1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
   2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
   3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
   4. Connect devices to branch circuits using pigtails that extend not less than 6 inches (152 mm) from wall.
   5. “Daisy-chaining” of receptacles is not permitted.
   6. Use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
   7. Use a torque screwdriver when a torque is recommended or required by manufacturer.
   8. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
   9. Tighten unused terminal screws on the device.
   10. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:
   1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
G. Arrangement of Devices: mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.

H. Adjust locations of floor service outlets to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."

B. Identify each receptacle with panelboard identification and circuit number. Receptacles rated more than 120V shall have voltage identified. Use hot, stamped or engraved machine printing with black-filled lettering on white field for normal circuits, red-filled lettering on white field for essential circuits, self adhesive nameplate attached to face of plate, and durable wire markers or tags inside outlet boxes.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 20-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

C. Wiring device will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports, and plan drawing(s) map indicating locations of all GFCI and AFCI receptacles. Submit to University Electric Shop.

END OF SECTION 26 2726
SECTION 26 2813 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Related Sections include the following:

1. Division 26 Section "Enclosed Switches and Circuit Breakers" for fusing in disconnect switches.
2. Division 26 Section "Enclosed Controllers" for fusing in motor starters.

1.2 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600-V ac and less for use in:
   a. Control circuits.
   b. Switchboards.
   c. Enclosed controllers.
   d. Enclosed switches.
   e. Elevator switches.
2. Spare-fuse cabinets.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material, dimensions, descriptions of individual components, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
   a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
   b. Provide manufacturer’s technical data on which ambient temperature adjustment calculations are based.

2. Dimensions and manufacturer’s technical data on features, performance, electrical characteristics, and ratings.
4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.
5. Coordination charts and tables and related data.
6. Fuse sizes for elevator feeders and elevator disconnect switches.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01, include the following:

1. Ambient temperature adjustment information.
2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.
4. Coordination charts and tables and related data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three (3) of each size and type.
2. Fuse Pullers: Provide for each size of fuse.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by UL and marked for intended location and application.

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Comply with most current edition of the Northwestern University Design Standards.

1.7 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (5 deg C) or more than 100 deg F (38 deg C), apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.8 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products by the following:
   1. Cooper Bussmann, Inc. (Eaton Corp. Electrical Group)

B. The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

2.3 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
   1. Size of cabinet: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
   2. Finish: Gray, baked enamel.
   3. Identification: "SPARE FUSES" in 1-1/2-inch- (38-mm-) high letters on exterior of door.
   4. Fuse Pullers: Provide for each size of fuse.
   5. List of fuse sizes/types provided.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

E. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2  FUSE APPLICATIONS

A. Provide fuses in accordance with equipment nameplates and manufacturers’ requirements.

B. Cartridge Fuses:

1. Motor/VFD Branch Circuits: Class RK1, time delay.
2. Other Branch Circuits: Class RK1, time delay.
3. Feeder or Large Motor Circuits 601 - 4000A: Class L, time delay.
5. Control Circuits: Class CC, time delay, and control transformer duty.

3.3  INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s) in main electric rooms and mechanical rooms as directed by University Electric Shop, stock with list of inventory, spares and fuse pullers.

3.4  IDENTIFICATION

A. Install labels complying with requirements for identification specified in Division 26 Section “Identification for Electrical Systems” and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, and holder.

END OF SECTION 26 2813
SECTION 26 2816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes Separately Mounted:
   1. Fusible switches.
   2. Non-fusible switches.
   3. Molded-case circuit breakers (MCCBs).
   5. Enclosures.

B. Related Sections:
   1. Division 26 Section "26 2813" for fusing requirements.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers’ technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

   1. Enclosure types and details for types other than NEMA 250, Type 1.
   2. Current and voltage ratings.
   3. Short-circuit current ratings (interrupting and withstand, as appropriate).
   4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
   5. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.
B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

B. Manufacturer’s field service report.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer’s written instructions for testing and adjusting enclosed switches and circuit breakers.
2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: 10%, but not no fewer than three (3) of each size and type.
2. Fuse Pullers: one for each size and type.

1.8 QUALITY ASSURANCE

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by UL and marked for intended location and application.

D. Comply with NFPA 70.

E. Comply with most current edition of the Northwestern University Design Standards.
F. Use of “General Duty” switches or equipment is prohibited.

G. Series rated equipment shall not be used.

1.9 PROJECT CONDITIONS

A. (Delete This Paragraph If Not Required) [Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by The University or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify the University no fewer than [two] calendar weeks in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electrical service without the University’s Chief Electrician’s written permission.
4. The University Lock-out/Tag-out procedures shall be used with Contractor controlled locks and tags.
5. Comply with NFPA 70E.]

B. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).

1.10 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels to comply with NEC Art. 110.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

A. Subject to compliance with requirements, provide products by one of the following:

1. Eaton Corp. Electrical Group
2. Siemens Industry Inc.
3. Schneider (Square D)

B. Type HD, Heavy Duty, Single Throw, [240] [600] -V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories: (Edit For Project Requirements)

1. Equipment Ground Kit: Internally mounted and labeled for copper ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: One NO/NC (Form “C”) auxiliary contact(s), arranged to activate before switch blades open.
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: Mechanical type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.

2.2 NONFUSIBLE SWITCHES

A. Subject to compliance with requirements, provide products by one of the following:
   2. Siemens Industry Inc.

B. Type HD, Heavy Duty, Single Throw, [240] [600]-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories: (Edit For Project Requirements)
   1. Equipment Ground Kit: Internally mounted and labeled for copper ground conductors.
   2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper neutral conductors.
   3. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper neutral conductors.
   4. Auxiliary Contact Kit: One NO/NC (Form “C”) auxiliary contact(s), arranged to activate before switch blades open.
   5. Hookstick Handle: Allows use of a hookstick to operate the handle.
   6. Lugs: Mechanical type, suitable for number, size, and conductor material.
   7. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

2.3 MOLDED-CASE CIRCUIT BREAKERS

A. Subject to compliance with requirements, provide products by one of the following:
   2. Siemens Industry Inc.

B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, fully rated with interrupting capacity to comply with available fault currents.

C. Circuit breakers 250 Amps and larger shall be rated to carry 100% of their current rating continuously.

D. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A up to 400 A.
E. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

F. Electronic Trip Circuit Breakers: 400 A and larger. Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
   1. Instantaneous trip.
   2. Long- and short-time pickup levels.
   3. Long- and short-time time adjustments.
   4. Ground-fault pickup level, time delay, and \(I^2t\) response.


I. Features and Accessories:
   1. Standard frame sizes, trip ratings, and number of poles.
   2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
   3. Application Listing: Appropriate for application.
   4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
   5. Communication Capability: Integral communication module with functions and features compatible with the University’s SCADA system.
   6. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
   7. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
   8. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
   9. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
  10. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
   11. Electrical Operator: Provide remote control for on, off, and reset operations.

J. New Circuit Breakers in Existing Panelboards:
   1. Circuit breakers shall be of standard manufacture and match existing devices.
   2. Circuit breakers shall be “bolt-on” type.
   3. Circuit breakers shall have an AIC rating compatible with the Building’s short circuit analysis report.

2.4 ACCESSORIES

A. Communication modules: Where indicated provide communication modules, energy metering and control for circuit breakers and switches, with functions and features compatible with the
University’s SCADA network. Communications link shall be via the University’s energy management software.

2.5 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.
4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
5. Hazardous Areas Indicated on Drawings: NEMA 250, [Type 7] [Type 9].

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated. Install switches and circuit breakers on walls by mounting on lightweight structural-steel channels such as “Uni-Strut” bolted to wall. Do not “stack” devices.

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

C. Install wiring between circuit breakers and switches, and University’s SCADA network.

1. Install all low voltage wiring (CAT. 6, twisted pair, etc.) between energy metering devices and the University’s SCADA network.

D. Install fuses in fusible devices in accordance with Manufacturer’s recommendations or equipment nameplates.

E. Provide GFI circuit breakers with 30 mA sensitivity trip for all freeze protection, temperature maintenance, and heat tracing circuits.

F. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Division 26 Section “Identification for Electrical Systems.”
1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Acceptance Testing Preparation:
   1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

C. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection report, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges. Provide list of “as left” settings and submit to Electric Shop.

END OF SECTION 26 2816
ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes controllers separately enclosed and mounted, rated 600 V and less:

1. Full-voltage manual.
2. Full-voltage magnetic.

B. Related Section:

1. Division 23 Section "Variable-Frequency Motor Controllers" for general-purpose, ac, adjustable-frequency, pulse-width-modulated controllers for use on variable torque loads in ranges up to 200 hp.
2. Division 26 Section "26 2813" for fusing requirements.

1.3 DEFINITIONS

A. CPT: Control power transformer.


C. N.O.: Normally open.

D. OCPD: Overcurrent protective device.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of enclosed controller. Include manufacturer's technical data on features, performance, electrical characteristics, ratings, and enclosure types and finishes.

B. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.

1. Show tabulations of the following:

   a. Each installed unit's type and details.
   b. Factory-installed devices.
   c. Nameplate legends.
   d. Short-circuit current rating of integrated unit.
e. Listed and labeled for integrated short-circuit current (withstand) rating of OCPD’s in combination controllers by an NRTL acceptable to authorities having jurisdiction.

f. Features, characteristics, ratings, and fusing of individual OCPD’s in combination controllers.

2. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for enclosed controllers and installed components.
2. Manufacturer’s written instructions for fusing requirements.
3. Manufacturer’s written instructions for setting field-adjustable overload relays.

1.7 MATERIALS MAINTENANCE SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

1.8 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by UL and marked for intended location and application.

B. Comply with NFPA 70.

C. Comply with most current edition of the Northwestern University Design Standards.

D. Use of IEC rated components is prohibited.

E. Controllers shall be a minimum of NEMA size 1.
1.9 DELIVERY, STORAGE, AND HANDLING

A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

B. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers.

1.10 PROJECT CONDITIONS

A. **(Delete This Paragraph If Not Required)** [Interruption of Existing Electrical Systems: Do not interrupt electrical systems in facilities occupied by the University or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify the University no fewer than [two] calendar weeks in advance of proposed interruption of electrical systems.
2. Indicate method of providing temporary utilities.
3. Do not proceed with interruption of electrical service without the University’s Chief Electrician’s written permission.
4. The University Lock-out/Tag-out procedures shall be used with Contractor controlled locks and tags.
5. Comply with NFPA 70E.]

B. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).

1.11 COORDINATION

A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

1.12 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace controllers that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Ten years from date of Substantial Completion.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following:

2. Siemens Industry Inc.
3. Schneider (Square D)

2.2 FULL-VOLTAGE CONTROLLERS

A. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.

B. Motor-Starting Switches: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.

2. [Flush] [Surface] mounting as indicated on drawings.

C. Fractional Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.

2. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type.
3. [Flush] [Surface] mounting as indicated on drawings.
5. [N.O.] [N.C.] auxiliary contact.

D. Integral Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.

2. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 20 tripping characteristics; heaters and sensors in each phase, matched to nameplate full-load current of actual protected motor and having appropriate adjustment for duty cycle; external reset push button; bimetallic type.
3. [Flush] [Surface] mounting as indicated on drawings.

E. Magnetic Controllers: Full voltage, across the line, electrically held.

2. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.
   a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
3. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

4. Control Circuits: 120 V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity, minimum 500VA, to operate integral devices and remotely located pilot, indicating, and control devices.
   a. CPT Spare Capacity: 100%.

5. Bi-Metallic Thermal Overload Relays:
   a. Inverse-time-current characteristic.
   b. Class 20 tripping characteristic.
   c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
   d. Isolated alarm contact.

6. External overload reset push button.

F. Combination Magnetic Controller: Factory-assembled combination of magnetic controller, OCPD, and disconnecting means.
   1. Fusible Disconnecting Means:
      a. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class R fuses.
      b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
      c. Auxiliary Contacts: N.O. /N.C., arranged to activate before switch blades open.

2.3 ENCLOSURES

A. Separately Mounted Enclosed Controllers: NEMA ICS 6, NEMA 250, to comply with environmental conditions at installed location. [Select All That Apply]
   1. Dry and Clean Indoor Locations: Type 1.
   2. Outdoor Locations: Type 3R.
   4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.
   5. Hazardous Areas Indicated on Drawings: Type 7 or Type 9 as indicated.

2.4 ACCESSORIES

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.
      a. Push Buttons: Shrouded types; [maintained] or [momentary] as indicated.
      b. Pilot Lights: LED types; colors as indicated; push to test.
      c. Selector Switches: Rotary type.

B. Reversible N.C. /N.O. auxiliary contact(s) as indicated.
C. Control Relays: Auxiliary and adjustable solid-state time-delay relays as indicated.


E. Communications Modules: Where indicated provide communication modules, energy metering and control in motor starters with functions and features compatible with the University's SCADA system. Provide all communications wiring between remote metering and communication modules and the University's SCADA system.

F. Breather and drain assemblies, to maintain interior pressure and release condensation in Type 4X, Type 7, Type 9 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

G. [Space heaters, with N.C. auxiliary contacts, to mitigate condensation in Type 3R enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.]

H. Cover gaskets for Type 1 enclosures.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and surfaces to receive enclosed controllers, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.

B. Examine enclosed controllers before installation. Reject enclosed controllers that are wet, moisture damaged, or mold damaged.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks of “Uni-Strut” and/or galvanized steel anchored to floors.

B. Floor-Mounted Controllers: Install enclosed controllers on 4-inch (Evanston: 6-inch high east of Sheridan Rd.) nominal-thickness concrete base. Comply with requirements for concrete base specified in Division 03 Sections.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.

2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in each fusible-switch enclosed controller in accordance equipment nameplates. Comply with requirements in Division 26 Section "Fuses."

E. Install fuses in control circuits if not factory installed. Comply with requirements in Division 26 Section "Fuses."

F. Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

G. Install spare-fuse cabinet(s) in electric rooms and mechanical rooms as directed by University Electric Shop and stock as required by Division 26 Section "Fuses."

H. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

3.4 CONTROL WIRING INSTALLATION

A. Install wiring between enclosed controllers and remote devices and facility's central control system. Comply with requirements in Division 26 Section "Control-Voltage Electrical Power Cables."

1. Install all low voltage wiring (CAT. 6, twisted pair, etc.) between energy metering devices and The University's SCADA network.

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control selection devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
2. Connect selector switches with enclosed-controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.5 FIELD QUALITY CONTROL

A. Tests and Inspections:
1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at controller locations are within plus or minus 10 percent of motor nameplate rated voltages.
5. Test each motor for proper phase rotation.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

B. Enclosed controllers will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports including a certified report that identifies enclosed controllers and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3.6 ADJUSTING

A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

B. Adjust overload-relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.

3.7 CLEANING

A. Vacuum dirt and debris from enclosures prior to substantial completion; do not use compressed air to assist in cleaning.

3.8 PROTECTION

A. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.9 DEMONSTRATION

A. Train The University's maintenance personnel to adjust, operate, and maintain enclosed controllers.

END OF SECTION 26 2913
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes packaged, outdoor, [all projects unless variance approved in writing by the Chief Electrician] engine-generator sets for Level 1 emergency power supply with the following features:
   1. Diesel engine.
   2. Unit-mounted cooling system.
   3. Unit-mounted control and monitoring.
   4. Performance requirements for sensitive loads.
   5. Integral fuel tank.
   7. Outdoor enclosure.

B. Related Sections:
   1. Division 26 Section 26 3600 “Transfer Switches” for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

1.3 DEFINITIONS

A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.4 SUBMITTALS

A. Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:
   1. Thermal damage curve for generator.
   2. Catalog data for generator protective device.
   3. Time-current characteristic curves for generator protective device.

B. Shop Drawings: “Typical” drawings are not acceptable. Provide project specific drawings for engine-generator and all specified components. Drawings shall detail equipment assemblies
and indicate dimensions, weights, loads, and required clearances, method of field assembly, components, and location and size of each field connection.

1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified including enclosure.
2. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.

C. Qualification Data: For manufacturer.

D. Source quality-control test reports.

1. Certified summary of prototype-unit test report.
2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
6. Report of exhaust emissions showing compliance with applicable regulations.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section “Operation and Maintenance Data,” include the following:

1. List of tools and replacement items recommended for storage at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.

G. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

1. Maintenance Proximity: Not more than two hours' normal travel time from Installer's place of business to Project site.
2. Engineering Responsibility: Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.

B. Manufacturer Qualifications: A Firm experienced in the manufacturing of equipment of the type and capacity described herein and have a verifiable successful in-service performance record. Manufacturer shall maintain within 50 miles of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.
C. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by UL and marked for intended use.

E. Comply with ASME B15.1.

F. Comply with NFPA 30.

G. Comply with NFPA 37.

H. Comply with NFPA 70.

I. Comply with NFPA 110 requirements for Level 1 emergency power supply system.

J. Comply with latest EPA Tier requirements.

K. Comply with latest Illinois EPA requirements.

L. Comply with FM Global requirements.

M. Comply with most current edition of the Northwestern University Design Standards.

N. Engine Exhaust Emissions: Comply with applicable state and local government requirements.

O. Comply with UL 2200.

P. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.6 PROJECT CONDITIONS

A. (Delete This Paragraph If Not Required) [ Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by the University or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify the University’s Chief Electrician no fewer than seven days in advance of proposed electrical service interruptions.

2. Indicate method of providing temporary utilities.

3. Do not proceed with interruption of electrical service without the University’s Chief Electrician’s written permission.

4. The University Lock-out/Tag-out procedures shall be used with Contractor controlled locks and tags.

5. Comply with NFPA 70E.]

B. Installation Pathway: Remove and replace building components and structures to provide pathway for moving transformers into place.
C. Products Selection for Restricted Space: Drawings indicate maximum dimensions for generators including clearances between generators and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: Minus 15 to plus 40 deg C.
2. Relative Humidity: 0 to 95 percent.
3. Altitude: Sea level to 1000 feet (300 m).

1.7 COORDINATION

A. Coordinate size and location of concrete bases for package engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Sections.

1.8 WARRANTY

A. Comply with Division 1 requirements.

B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Beneficial Occupancy.

1.9 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include monthly exercising to check for proper starting, load transfer, and running under load and a yearly load bank test. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

1.10 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Three for each battery charger and control panel.
2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Caterpillar Inc.; Engine – Generator Division (no substitutions).

2.2 ENGINE-GENERATOR SET

A. Factory-assembled and -tested, engine-generator set.

B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.

C. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated, with capacity as required to operate as a unit as evidenced by records of prototype testing and providing a minimum of 168 hours run time at 100% rated power output of the generator.

2. Output Connections: Three-phase, four-wire.

3. Nameplates: For each major system component to identify manufacturer’s name and address, and model and serial number of component.

D. Generator-Set Performance:

1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.

   a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.

2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.

3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.

4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.

5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.

6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.

7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.

9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
   
a. Provide permanent magnet excitation for power source to voltage regulator.

10. Start Time: Comply with NFPA 110, Type 10, system requirements.

11. Accept rated load in one step.

12. If required by Project: [UPS load: ____% of connected].

2.3 ENGINE


B. Rated Engine Speed: 1800 rpm.

C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm (11.4 m/s).

D. Lubrication System: The following items are mounted on engine or skid:
   
   1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
   2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
   3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

E. Engine Fuel System:
   
   2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
   3. Fuel Filtering: Fuel/water separator to remove water and contaminants larger than 1 micron.

F. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.

G. Governor: Adjustable isochronous, with speed sensing.

H. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.
   
   1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
   2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.

4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

   a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and non-collapsible under vacuum.
   b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

I. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
   1. Minimum sound attenuation of 25 dB at 500 Hz.
   2. Sound level measured at a distance of 10 feet (3 m) from exhaust discharge after installation is complete shall be 85 dBA or less.
   3. Factory installed and piped.
   4. Weather-cap on outlet. (Delete For Indoor Units)

J. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

K. Starting System: [up to and including 250 kW] 12-V electric, with negative ground; [greater than 250 KW] 24-V electric, with negative ground.
   1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.
   2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
   3. Dual cranking motors. [For Units > 1000 KW]
   4. Cranking Cycle: As required by NFPA 110 for system level specified.
   5. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least three times without recharging. Battery shall be maintenance free, sealed lead acid type. [No Wet Cell Or NiCad]
   6. Battery bank for each cranking motor. [For Units > 1000 KW]
   7. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
   8. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Include accessories required to support and fasten batteries in place.
   10. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:
       a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.

c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.


e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.

f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

g. Provide one charger for each battery bank, provide products by La Marche.

2.4 FUEL OIL STORAGE

A. Comply with NFPA 30, NFPA 37, City of [Chicago] [Evanston], and State of Illinois Codes.

B. Skid Base Day Tank: Comply with UL 142, skid base, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:

1. Tank Capacity: As recommended by engine manufacturer for an uninterrupted period of minimum 24 hours' operation at 100 percent of rated power output of engine-generator system without being refilled. The skid base tank shall not be less than 12 inches in height.

2. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of tank.

   a. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of a leak.

3. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.

4. High-Level Alarm Sensor: Liquid-level device operates alarm and redundant fuel shutoff contacts at midpoint between overflow level and 100 percent of normal fuel level.

5. The fuel tank shall be equipped with a manual fuel level gauge capable of being seen by the operator to determine the fuel level in the tank.

6. The tank and all accessories shall be suitable for indoor [outdoor] use.

7. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.

8. [Vandal-resistant fill cap]. Outdoor units only

9. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, vent line, overflow line; and tank drain line with shutoff valve. The fuel tank shall be equipped with a manual fuel level gauge capable of being seen by the operator to determine the fuel level in the tank.

2.5 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of
same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.

B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.

C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring pane, microprocessor based, mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.

D. The control panel shall be designed and built by the engine manufacturer.

E. The control panel shall provide real time digital communications to all engine and regulator controls.

F. Control panel:
   1. The control shall include a backlight graphical display with text-based alarm/event descriptions.
   2. Audible horn for alarm and shutdown with horn silence switch
   3. Remote start/stop control
   4. Local run/off/auto control integral to system microprocessor
   5. Cool-down timer
   6. Speed adjust
   7. Lamp test
   8. Voltage adjust
   9. Voltage regulator V/Hz slope - adjustable
   10. Password protected system programming

G. Indicating Digital Readouts: As required by NFPA 110 for Level 1 system and the following:
   1. AC volts.
   2. AC amps.
   3. AC frequency.
   4. KW
   5. KVA.
   6. KVAR.
   7. Power Factor.
   8. KWH.
   9. Exciter voltage and current.
   10. DC voltmeter (alternator battery charging).
   11. Engine-coolant temperature.
   12. Engine lubricating-oil pressure.
   15. Ammeter-voltmeter, phase-selector switches.
   17. Fuel tank derangement alarm.
   18. Fuel tank high-level shutdown of fuel supply alarm.
19. Generator overload.
20. Engine RPM.

H. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

I. Network Communications: Communication Gateway, discrete I/O module, for each alarm and status indication for data-link transmission of indications to remote data terminals and control network. Generator shall be capable of communicating with Northwestern University’s existing SACDA network system.

1. The generator shall be seamlessly compatible with the existing campus generator monitoring Internet-based system.
2. The network shall be MOD-bus isolated data link through a standard RS-485 connection.
3. The distributed control, monitoring, and operation shall be connected to the University’s SCADA system.
4. The network media shall be a transformer coupled twisted pair with category 6 transmission capabilities.
5. The network shall monitor real time generator operating data, status, and alarms.
6. Provide remote control capability for the generator through the network.
7. Remote communications: provide devices, wiring, software and equipment for remote communications from the generator to the Building Automation System.
8. The Controller shall be capable of accepting digital input signals and operate programmable outputs integral to the Controller.
9. Provide Remote communications to the University’s ADT system for the following status:

   a. Generator “Fail”.
   b. Generator “Running”.
   c. Generator “Fault”.

J. Common Remote Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel for connection to the SCADA system.

1. Overcrank shutdown.
2. Coolant low-temperature alarm.
3. Coolant high-temperature alarm.
5. Low coolant level.
7. Control switch not in auto position.
8. Battery-charger malfunction alarm.
10. Battery high-voltage alarm.
11. Low oil pressure warning.
12. Low oil pressure shutdown.

K. Generator Alarm/Shutdown.

1. Generator over voltage.
2. Generator under voltage
3. Generator over frequency
4. Generator under frequency
5. Generator reverse power
6. Generator overcurrent

L. Voltage Regulator Alarm/Shutdown
   1. Loss of excitation alarm/shutdown
   2. Instantaneous over excitation alarm/shutdown
   3. Time over excitation alarm/shutdown
   4. Rotating diode failure
   5. Loss of sensing
   6. Loss of PMG

M. Remote Alarm Annunciator: Comply with NFPA 110 requirements for Level 1 systems. An LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated. The annunciator shall have the ability to be located up to 800 ft. from the generator set.

N. Generator exerciser:
   1. Programmable cycle timer that starts and runs the generator for a predetermined time. The timer shall use 14 user-programmable sequences that are repeated in a 7-day cycle. Each sequence shall have the following programmable set points:
      a. Day of week
      b. Time of day to start
      c. Duration of Cycle.

O. Remote Emergency-Stop Switch: Flush; wall mounted, [in weatherproof enclosure,] (select for outdoor units) unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.6 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Quantity of unit mounted output circuit breakers: [insert number]

B. Generator Circuit Breaker: [Molded Case, up to and including 400 A] [Insulated-case, above 400 A], electronic-trip type; complying with UL 489. Circuit breakers 250 Amps and larger shall be rated to carry 100% of their current rating continuously.
   1. All breakers shall be fully rated to interrupt the available fault current.
      a. Provide bypass switch to defeat instantaneous trip.
   3. Trip Settings: Selected to coordinate with generator thermal damage curve.
   4. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
   5. Mounting: Adjacent to or integrated with control and monitoring panel.
C. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

2.7 LOAD CONNECTION BOX

A. Provide a generator bus tap located in a connection box for connection of cables to a portable load bank. Size the bus tap for 100 percent full load current of the generator, with mechanical lugs for cable connections. Box shall have a bushed opening(s) sized for the cables and a hinged padlockable cover capable of being closed while the cables are connected.

2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.
B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
C. Electrical Insulation: Class H or Class F.
D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.
E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
F. Enclosure: Drip-proof.
G. Instrument Transformers: Mounted within generator enclosure.
H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
   1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.
I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
J. Windings: 0.6667 pitch stator winding and fully linked amortisseur winding.
K. Sub-transient Reactance: 12 percent, maximum.
L. Provide minimum motor starting capability of [insert number] sKVA at 30% instantaneous voltage dip as defined per NEMA MG 1.

2.9 MOTORS

A. General requirements for motors are specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven loads will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 26 Sections.

2.10 VIBRATION ISOLATION DEVICES

A. The isolators shall be of a waffled or ribbed pad. The pads shall be resistant to heat and age, and impervious to oil, water, antifreeze, diesel fuel, and cleaning compounds.

2.11 FINISHES

A. Indoor Enclosures and Components: Manufacturer’s standard finish over corrosion-resistant pretreatment and compatible primer.

2.12 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.


B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
2. Full load run.
3. Maximum power.
4. Voltage regulation.
5. Transient and steady-state governing.
7. Safety shutdown.
8. Provide 14 days' advance notice of tests and opportunity for observation of tests by the Northwestern University’s designated representative.
9. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.

B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 INSTALLATION

A. Comply with packaged engine-generator manufacturers’ written installation and alignment instructions and with NFPA 110.

B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

C. Install indoor engine generators on 4-inch- (100-mm-) high concrete base (Evanston: 6” high east of Sheridan Rd.). Secure sets to anchor bolts installed in concrete bases. Construct concrete bases according to Division 3 Sections.

D. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

E. Install remote Generator Annunciator Panel(s) (GAP) as indicated. Provide all interconnecting wiring.

3.3 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Tighten electrical joints, electrical connectors, and terminals according to manufacturer's published torque-tightening values using a calibrated torque wrench. Provide a list of all torqued connections and values.

D. Provide all communications wiring between generator's remote monitoring and communication modules and the University's SCADA system. Verify that each Generator's address for microprocessor-communication packages corresponds to data network requirements. Include all necessary programming by a factory-authorized service representative to link systems and permit data transfer between generator and SCADA.

E. Provide all interconnecting wiring between the generator and transfer switches as required for proper operation of system, provide a start circuit from each transfer switch.

F. Provide all interconnecting wiring between the generator and other equipment or systems as required for proper operation and monitoring of system.

G. **(Delete if not required)** [Provide control circuits from the fire pump controller to start the engine-generator.]

H. Provide control circuits from the engine-generator to BAS to provide "generator running" and "generator trouble" alarms.

I. Furnish and install all miscellaneous control and power wiring as required for a complete and functioning system that meets all University, AHJ, and Code requirements.
3.4 IDENTIFICATION

A. Identify system components according to Division 26 Section "Identification for Electrical Systems."

B. Emergency Sources: A sign shall be placed at the service entrance equipment indicating the type and location of on-site emergency power sources per NEC Art. 700.

3.5 ADJUSTING

A. Set engine-generator circuit breaker and relay protective functions.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. This Contractor is responsible for the following tests and inspections:

1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
3. The diesel generator set shall operate under full load conditions for a minimum of four (4) hours. The generator set shall maintain rated voltage and rated frequency per Specifications for the duration of the full load test. Voltage, amperage and frequency measurements, as well as engine gauge and monitor points, shall be recorded at 15 minute intervals. All doors of the weatherproof housing shall remain closed during testing.
4. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
   a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
   b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
   c. Verify acceptance of charge for each element of the battery after discharge.
   d. Verify that measurements are within manufacturer's specifications.
5. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
6. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
7. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120 kPa). Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer’s written allowable limits for the engine.

8. Exhaust Emissions Test: Comply with applicable government test criteria.

9. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.

10. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.

11. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line, and compare measured levels with required values.

D. Coordinate tests with tests for transfer switches and run them concurrently.

E. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

H. Remove and replace malfunctioning units and retest as specified above.

I. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

J. This Contractor shall top off all fuel/oil/coolant tanks at completion of testing. Fill all engine fluids to levels as recommended by manufacturer.

K. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations.

L. Infrared Scanning: After Substantial Completion, but not more than 90 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner. Generator shall be at running temperature under load conditions.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Northwestern University maintenance personnel to adjust, operate, and maintain packaged engine generators. Provide two - 8 hour sessions. Conduct this training concurrently with ATS training, refer to Section 263600.
SECTION 26 3323 - CENTRAL BATTERY EQUIPMENT [for Evanston campus only]

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
A. This Section includes [slow-transfer] [fast-transfer] central battery inverters used for emergency or life safety lighting circuits with the following features:

(Edit per project requirements)
1. Output distribution section.
2. Internal maintenance bypass/isolation switch.
3. External maintenance bypass/isolation switch.
4. Multiple output voltages.
5. Emergency-only circuits.

1.3 DEFINITIONS
A. LCD: Liquid-crystal display.
B. LED: Light-emitting diode.
C. THD: Total harmonic distortion.
D. UPS: Uninterruptible power supply.

1.4 ACTION SUBMITTALS
A. Product Data: For the following:
   1. Electrical ratings, including the following:
      a. Capacity to provide power during failure of normal AC.
      b. Inverter voltage regulation and THD of output current.
      c. Rectifier data.
      d. Transfer time of transfer switch.
      e. Data for specified optional features.
   2. Transfer switch.
3. Inverter.
4. Battery charger.
5. Batteries.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, components, and location and identification of each field connection. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.

   1. Wiring Diagrams: Detail internal and interconnecting wiring; and power, signal, and control wiring.
   2. Elevation and details of control and indication displays.
   3. Output distribution section.

1.5 INFORMATIONAL SUBMITTALS
A. Source quality-control test reports.
B. Field quality-control test reports.
C. Warranty: Special warranty specified in this Section.

1.6 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For central battery inverter equipment to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS
A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Deliver extra materials to the University Electric Shop.

   1. Fuses: One for every 10 of each type and rating, but no fewer than three of each.
   2. Cabinet Ventilation Filters: One complete set.
   3. One spare circuit board for each critical circuit boxed and labeled.

1.8 QUALITY ASSURANCE
A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by UL and marked for intended use.

B. Central Battery Inverter System: UL 924 and UL 1778 listed.
C. Comply with NFPA 70 and NFPA 101.
D. Comply with most current edition of the Northwestern University Design Standards.
1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver equipment in fully enclosed vehicles.

B. Store equipment in spaces having environments controlled within manufacturers’ written instructions for ambient temperature and humidity conditions for non-operating equipment.

1.10 PROJECT CONDITIONS

A. (Delete This Paragraph If Not Required) [Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by The University or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify the University’s Chief Electrician no fewer than ten (10) business days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary utilities.
3. Do not proceed with interruption of electrical service without the University’s Chief Electrician’s written permission.
4. The University Lock-out/Tag-out procedures shall be used with Contractor controlled locks and tags.
5. Comply with NFPA 70E.]

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for equipment, including clearances between equipment and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:

1. Ambient Temperature: Not exceeding 40 deg C.

1.11 WARRANTY

A. Comply with Division 1 requirements.

B. Special Warranty: Manufacturer’s standard form in which manufacturer agrees to repair or replace batteries that fails in materials or workmanship within specified warranty period. Special warranty, applying to batteries only, applies to materials only, on a prorated basis, for period specified.

1. Warranty Period: Include the following warranty periods, from date of Beneficial Occupancy:

   a. Inverter and Battery Charger: Ten (10) years.
   b. Premium, sealed, lead-calcium batteries:

      1) Full Warranty: Ten (10) years.
      2) Pro Rata: Fifteen (15) years.
2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2. Cooper Industries, Inc.; Sure-Lites Division.
3. Hubbell Incorporated; Hubbell Lighting.
4. Lithonia Lighting; Emergency Lighting Systems.
5. Myers Power Products.
6. Thomas & Betts Corporation; Emergi-Lite Division.

2.2 INVERTER PERFORMANCE REQUIREMENTS (select A or B below)

A. [Slow-Transfer Central Battery Inverters: Automatically sense loss of normal AC supply and use an electromechanical switch to transfer loads. Transfer in one second or less from normal supply to battery-inverter supply.]

1. Operation: Unit supplies power to output circuits from a single, external, normal supply source. Unit automatically transfers load from normal source to internal battery/inverter source. Retransfer to normal is automatic when normal power is restored.]

B. [Fast-Transfer Central Battery Inverters: Automatically sense loss of normal AC supply and use a solid-state switch to transfer loads. Transfer in 0.004 second or less from normal supply to battery-inverter supply.]

1. Operation: Unit supplies power to output circuits from a single, external, normal supply source. Unit automatically transfers load from normal source to internal battery/inverter source. Retransfer to normal is automatic when normal power is restored.]

C. Maximum Acoustical Noise: less than 50 dB, "A" weighting, emanating from any component under any condition of normal operation, measured 39 inches (990 mm) from nearest surface of component enclosure.

2.3 SERVICE CONDITIONS

A. Environmental Conditions: Inverter system shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Ambient Temperature for Electronic Components: 32 to 98 deg F (0 to 37 deg C).
2. Relative Humidity: 0 to 95 percent, non-condensing.
3. Altitude: Sea level to 4000 feet (1220 m).
2.4 INVERTERS

A. Description: Solid-state type, with the following operational features:

1. Automatically regulate output voltage to within plus or minus 5 percent.
2. Automatically regulate output frequency to within plus or minus 1 Hz, from no load to full load at unit power factor over the operating range of battery voltage.
3. Output Voltage Waveform of Unit: Sine wave with maximum 10 percent THD throughout battery operating-voltage range, from no load to full load.
   a. THD may not exceed 5 percent when serving a resistive load of 100 percent of unit rating.
5. Output Protection: Ferroresonant transformer to provide inherent overload and short-circuit protection.
7. Overload Capability: 125 percent for 10 minutes; 150 percent surge.
8. Brownout Protection: Produces rated power without draining batteries when input voltage is down to 75 percent of normal.

2.5 BATTERY CHARGER

A. Description: Solid-state, automatically maintaining batteries in fully charged condition when normal power is available. With LED indicators for “float” and “high-charge” modes.

2.6 BATTERIES

A. Description: Premium, maintenance free, sealed lead-calcium batteries.

1. Capable of sustaining full-capacity output of inverter unit for minimum of 90 minutes.

2.7 ENCLOSURES

A. NEMA 250, Type 1 steel cabinets with access to components through hinged doors with flush tumbler lock and latch.

B. Finish: Manufacturer’s standard baked-enamel finish over corrosion-resistant prime treatment.

2.8 CONTROL AND INDICATION

A. Description: Group displays, indications, and basic system controls on common control panel on front of central battery inverter enclosure.

B. Minimum displays, indicating devices, and controls shall include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms shall include an audible signal and a visual display.
C. Indications: Plain-language messages on a digital LCD or LED (typically for units >10 KVA). (edit list for project requirements)

1. Quantitative Indications:
   a. Input voltage, each phase, line to line.
   b. Input current, each phase, line to line.
   c. System output voltage, each phase, line to line.
   d. System output current, each phase.
   e. System output frequency.
   f. DC bus voltage.
   g. Battery current and direction (charge/discharge).
   h. Elapsed time-discharging battery.

2. Basic Status Condition Indications:
   a. Normal operation.
   b. Load-on bypass.
   c. Load-on battery.
   d. Inverter off.
   e. Alarm condition exists.

3. Alarm Indications:
   a. Battery system alarm.
   b. Control power failure.
   c. Fan failure.
   d. Overload.
   e. Battery-charging control faulty.
   f. Input overvoltage or undervoltage.
   g. Approaching end of battery operation.
   h. Battery undervoltage shutdown.
   i. Inverter fuse blown.
   j. Inverter transformer overtemperature.
   k. Inverter overtemperature.
   l. Static bypass transfer switch overtemperature.
   m. Inverter power supply fault.
   n. Inverter output overvoltage or undervoltage.
   o. System overload shutdown.
   p. Inverter output contactor open.
   q. Inverter current limit.

4. Controls:
   a. Inverter on-off.
   b. Start.
   c. Battery test.
   d. Alarm silence/reset.
   e. Output-voltage adjustment.

D. Dry-form "C" contacts shall be available for remote indication of the following conditions:

1. Inverter on battery.
2. Inverter on-line.
3. Inverter load-on bypass.
4. Inverter in alarm condition.
5. Inverter off (maintenance bypass closed).

E. Include the following minimum array:

1. Ready, normal-power on light.
2. Charge light.
3. Inverter supply load light.
4. Battery voltmeter.
5. AC output voltmeter with minimum accuracy of 2 percent of full scale.
7. Test switch to simulate AC failure.

F. Enclosure: Steel, with hinged lockable doors, suitable for [wall] [floor] mounting. Manufacturer's standard corrosion-resistant finish.

2.9 MONITORING/CONTROL BY REMOTE COMPUTER

A. Coordinate remote monitoring and control communication module package with the University's SCADA network for successful transmission and remote readout of monitoring data and UPS Control. Connect remote monitoring communication module to the University's SCADA network through appropriate network interface unit. The manufacturer shall wire between all communications capable devices within the equipment, including electronic meters with the same protocol and wire to a set of easily accessible terminal blocks.

B. Description: Communication module in unit control panel provides capability for remote monitoring of status, parameters, and alarms specified in “Controls and Indications” paragraphs. The remote computer and the connecting signal wiring are not included in this Section. Include the following features:

1. SCADA interface units for data transmission via Modbus TCP/IP.

2.10 OPTIONAL FEATURES

A. Multiple Output Voltages: Supply unit branch circuits at different voltage levels if required. Transform voltages internally as required to produce indicated output voltages.

B. Emergency-Only Circuits: Automatically energize only when normal supply has failed. Disconnect emergency-only circuits when normal power is restored.

C. Maintenance Bypass/Isolation Switch: Switch is interlocked so it cannot be operated unless static bypass transfer switch is in bypass mode. Switch provides manual selection among the following three conditions without interrupting supply to the load during switching:

1. Full Isolation: Load is supplied, bypassing central battery inverter system. Normal AC input circuit, static bypass transfer switch, and central battery inverter load terminals are completely disconnected from external circuits.
2. Maintenance Bypass: Load is supplied, bypassing central battery inverter system. Central battery inverter AC supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
3. Normal: Normal central battery inverter AC supply terminals are energized and the load is supplied either through static bypass transfer switch and central battery inverter rectifier-charger and inverter or through battery and inverter.

2.11 OUTPUT DISTRIBUTION SECTION

A. Panelboard: Comply with Division 26 Section "Panelboards" except provide assembly integral to equipment cabinet.

2.12 SYSTEM MONITORING AND ALARMS

A. Remote Status and Alarm Panel: Labeled LED’s on panel faceplate shall indicate five basic status conditions. Audible signal indicates alarm conditions. Silencing switch in face of panel silences signal without altering visual indication.

1. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.

B. Provisions for Remote Computer Monitoring: Communication module in unit control panel provides capability for remote monitoring of status, parameters, and alarms specified in Part 2 "Control and Indication" Article. Include the following features:

1. Connectors and network interface units for data transmission to University’s SCADA system.
2. Software shall be designed to control and monitor inverter system functions and to provide on-screen explanations, interpretations, diagnosis, action guidance, and instructions for use of monitoring indications and development of reports. Include capability for storage and analysis of power-line transient records.

C. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.

1. Annunciation of Alarms: At inverter system control panel.

D. Battery Monitoring: Battery Monitoring and Data Management System shall monitor the battery system. The system shall be capable of automatically monitoring, displaying, and recording all battery parameters described in this specification. The battery monitoring system shall transmit all battery data to a Remote Central Computer RCC via USB or RS-232, or be capable of being polled over a LAN/WAN connection using TCP/IP.

1. Basic Functional Performance: Automatically measures and records each discharge event, classifies it according to duration category, and totals discharges according to warranty criteria, displaying remaining warranted battery life on integral display.
2. Additional monitoring functions and features shall include the following:
   a. Measuring and recording of total voltage at battery terminals; providing alarm for excursions outside proper float voltage level.
   b. Monitoring of ambient temperature at battery and initiating an alarm if temperature deviates from normally acceptable range.
   c. Alarm contacts arranged to alarm for battery discharge events, abnormal temperature, abnormal battery voltage or temperature.
   d. Memory device to store recorded data in nonvolatile electronic memory.
E. Factory test complete inverter system, including battery, before shipment. Include the following:

   1. Functional test and demonstration of all functions, controls, indicators, sensors, and protective devices.
   2. Full-load test.
   4. Overload test.
   5. Power failure test.

F. Report test results. Include the following data:

   1. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
   2. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
   3. List of instruments and equipment used in factory tests.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance.

   1. Verify that manufacturer’s written instructions for environmental conditions have been permanently established in spaces where equipment will be installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall mounted system components. Do not attach directly to walls. Attach by bolting to steel channels such as “Uni-Strut”.

B. Install floor mounted system components on concrete base and attach by bolting.

   1. Concrete Bases: 4 inches (100 mm) high, (Evanston: 6 inches east of Sheridan Rd.) reinforced, with chamfered edges. Extend base no more than 3 inches (75 mm) in all directions beyond the maximum dimensions of equipment unless otherwise indicated.
   2. Place and secure anchorage devices. Use supported equipment manufacturer’s setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   3. Install anchor bolts according to anchor-bolt manufacturer’s written instructions.
   4. Use 3000-psi (20.7-MPa) 28-day compressive-strength concrete and reinforcement as specified in Division 03 Sections.
C. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

D. Install remote mounted status panels where indicated.

3.3 CONNECTIONS

A. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams, unless otherwise indicated.
   1. Provide wiring between unit and remote status monitoring panel.

B. Provide all communications wiring between remote monitoring/control and communication modules and the University's SCADA system.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
   1. Separately Derived Systems: Make grounding connections to grounding electrodes and bonding connections to metallic piping systems as indicated; comply with NFPA 70.

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 IDENTIFICATION

A. Identify equipment and components according to Division 26 Section "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:
   1. Inspect interiors of enclosures for integrity of mechanical and electrical connections, component type and labeling verification, and ratings of installed components.
   2. Test manual and automatic operational features and system protective and alarm functions.
   3. Test communication of status and alarms to remote monitoring equipment.
   4. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specifications. Certify compliance with test parameters.
   5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.
3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Verify that central battery inverter is installed and connected according to the Contract Documents.

C. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 26 Sections.

D. Complete installation and startup checks according to manufacturer's written instructions.

3.7 ADJUSTING AND CLEANING

A. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

B. Install new filters in each equipment cabinet within 14 days from date of Substantial Completion.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train the University's maintenance personnel to adjust, operate, and maintain central battery inverters. Provide eight (8) hours of classroom and hands-on training.

END OF SECTION 26 3323
PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. On-line, double-conversion, static-type, UPS units. UPS systems shall be designed with modular assemblies that allow user flexibility for operation as a fixed capacity system or as a modular redundant system. Systems may be deployed with various combinations of hardware and software scalability for growth and application flexibility. Key system features and accessories may include:

   a. UPS module(s) containing Rectifier(s), Inverter(s), Battery Charger(s), Static Bypass, and associated Control and Monitor Panel.
   b. Battery string(s) in UPS enclosure or in external Line-and-Match Battery Cabinets.
   c. Surge suppression.
   d. Line-and-Match and/or sidecar-type accessory cabinets for transformer, maintenance bypass, parallel tie and distribution applications.
   e. Non-matching wall mounted or floor standing maintenance bypass cabinets or multi-module parallel tie cabinets.
   f. Battery monitoring.

B. Related Sections:

   1. Division 26 Section "Grounding and Bonding for Electrical Systems".
   2. Division 26 Section "Low Voltage Electrical Power Conductors and Cables".

1.2 SUBMITTALS

A. Product Data: For each type of product indicated. Include data on features, components, ratings, and performance.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, components, and location and identification of each field connection. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement. Include wiring diagrams.

C. Factory Test Reports: Comply with specified requirements.

D. Field quality-control reports.

E. Operation and Maintenance Data:

F. Warranties.
1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 and marked for intended location and application.

B. UL Compliance: Listed and labeled under UL 1778.

C. NFPA Compliance: Mark UPS components as suitable for installation in computer rooms according to NFPA 75.

D. Comply with most current edition of the Northwestern University Design Standards.

1.4 PROJECT CONDITIONS

A. (Delete This Paragraph If Not Required) [Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by the University or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify the University’s Chief Electrician no fewer than seven days in advance of proposed electrical service interruptions.
2. Indicate method of providing temporary utilities.
3. Do not proceed with interruption of electrical service without the University’s Chief Electrician’s written permission.
4. The University Lock-out/Tag-out procedures shall be used with Contractor controlled locks and tags.
5. Comply with NFPA 70E.]

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for equipment, including clearances between equipment and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:

1. Ambient Temperature: Not exceeding 40 deg C.

1.5 WARRANTY

A. Comply with Division 1 requirements.

B. Special Battery Warranties:

1. Comply with Division 1 requirements.
2. UPS System warranty: one year.
3. UPS manufacturer warrants, that the VRLA Battery Products are free from defects in material and workmanship. A battery will not be considered defective or nonconforming if it has delivered at least eighty percent (80%) of its rated capacity during the Warranty Period.
4. If a Warranted Item is defective, manufacturer will refurbish or replace such defective Warranted Item (including the costs of providing diagnosis, service, and labor.
5. The Battery Warranty period shall be:
a. Battery Labor: Twelve (12) months from the date of product installation.
b. Batteries two hundred (200) watts per cell and greater: Thirty-six (36) months from the date of installation or forty-two (42) months from the manufacturing date code listed on the battery.
c. Batteries less than two hundred (200) watts per cell and greater, twenty-four (24) months from the date of installation or thirty (30) months the manufacturing date code listed on the battery.

C. Special UPS Warranties: Specified form in which manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within special warranty period.

1. Special Warranty Period: [Ten] years from date of factory startup completion or from the date that the system was energized and placed into service.

PART 2 - PRODUCTS

2.1 MANUFACTURED SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton Corporation.
2. Liebert Corporation.
3. Mitsubishi.

2.2 OPERATIONAL REQUIREMENTS

A. Automatic operation includes the following:

1. Normal Conditions: Load is supplied with power flowing from the normal power input terminals through the system with full ability to provide voltage regulation and battery backup if required.
2. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the system shall provide voltage regulation and/or battery backup as required.
3. If normal power fails, energy supplied by the battery through the inverter continues supply-regulated power to the load without switching or disturbance.
4. When power is restored at the normal supply terminals of the system, controls automatically synchronize the inverter with the external source before transferring the load. The rectifier-charger then supplies power to the load through the inverter and simultaneously recharges the battery.
5. If the battery becomes discharged and normal supply is available, the rectifier-charger charges the battery. On reaching full charge, the rectifier-charger automatically shifts to float-charge mode.
6. If any element of the UPS system fails and power is available at the normal supply terminals of the system, the static bypass transfer switch switches the load to the normal AC supply circuit without disturbance or interruption.
7. If a fault occurs in the system supplied by the UPS, and current flows in excess of the overload rating of the UPS system, the static bypass transfer switch operates to bypass the fault current to the normal AC supply circuit for fault clearing.
8. When the fault has cleared, the static bypass transfer switch returns the load to the UPS system.
9. If the battery is disconnected, the UPS continues to supply power to the load with no degradation of its regulation of voltage and frequency of the output bus.

B. Manual operation includes the following:

1. System shall have the ability to be manually transferred to bypass for maintenance or service without disturbance or interruption to the connected load.

C. Maintenance Bypass/Isolation Switch Operation: Switch is interlocked so it cannot be operated unless the static bypass transfer switch is in the bypass mode. Device provides manual selection among the three conditions in subparagraphs below without interrupting supply to the load during switching:

1. Full Isolation: Load is supplied, bypassing the UPS. Normal UPS AC input circuit, static bypass transfer switch, and UPS load terminals are completely disconnected from external circuits.
2. Maintenance Bypass: Load is supplied, bypassing the UPS. UPS AC supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
3. Normal: Normal UPS AC supply terminals are energized and the load is supplied through either the static bypass transfer switch and the UPS rectifier-charger and inverter, or the battery and the inverter.

D. Environmental Conditions: The UPS shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability, except battery performance.

1. Ambient Temperature for Battery: 77 +/- 9 Deg F (25 +/- 5 deg C).
2. Relative Humidity: 0 to 95 percent, non-condensing.
3. Altitude: Sea level to 4000 feet (1220 m).

2.3 PERFORMANCE REQUIREMENTS

A. The UPS shall perform as specified in this article while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a load crest factor of 3.0, under the following conditions or combinations of the following conditions:

1. Inverter is switched to battery source.
2. Steady-state ac input voltage deviates from +10% to -15% from nominal voltage.
3. Steady-state input frequency deviates up to +/- 5 percent from nominal frequency.
4. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of 5 percent of the fundamental value.
5. Load is 100 percent unbalanced continuously.

B. Minimum Duration of Supply: 10 minutes with full-rated output kW.

C. Input Voltage Tolerance: System steady-state and transient output performance remains within specified tolerances when steady-state AC input voltage varies between +10% and -15% from nominal.
D. Overall UPS Efficiency: All systems shall be available with energy saving operating modes that minimize losses without compromising power quality or reliability. Maximum efficiency shall be achieved during normal operating conditions.

1. Equal to or greater than 99% for 3 phase 480V systems rated between 20 - 3,000 kW.
2. Equal to or greater than 97% for 3 phase 208V systems rated between 12 – 60 kW.
3. Equal to or greater than 96% for 1 phase systems rated 3 -15kW.

E. Maximum Acoustical Noise: 65 dBa, emanating from any UPS component under any condition of normal operation, measured 1 meter from nearest surface of component enclosure.

F. Maximum Energizing Inrush Current: Six times the full-load current.

G. Maximum AC Output-Voltage Regulation for Loads up to 100 Percent Unbalanced: Plus or minus 2 percent over the full range of battery voltage.

H. Output Frequency: 60 Hz, plus or minus 0.5 percent over the full range of input voltage, load, and battery voltage.

I. Limitation of harmonic distortion of input current to the UPS shall be as follows: Input current total harmonic distortion (THD) shall be less than 3% at nominal line voltage and 5% nominal source impedance.

J. Maximum Harmonic Content of Output-Voltage Waveform: 1% total harmonic distortion (THD) for linear loads, 5% THD for 100% non linear loads crest factor of 3.1 without de-rating.

1. Linear load: Output voltage THD of less than 1% for 100% linear load.
2. Non-linear load: Output voltage THD of less than 5% for 100% non-linear load.

K. Minimum Overload Capacity of UPS at Rated Voltage:

1. Double Conversion mode: The unit shall maintain voltage regulation for 102% to <110% of resistive/inductive load for 10 minutes, 111% to <125% for 60 seconds, and 126% to 150% for 10 seconds, >151% for 300ms.
2. Stored energy mode (typically on battery): The unit shall maintain voltage regulation for 102% to <110% of resistive/inductive load for 10 minutes, 111% to <125% for 60 seconds, and >126% for 300ms.
3. Energy Saver System operation: Continuous = 110%. Transient = 1000% peak current for 10ms.
4. On bypass (single UPS systems): Continuous = 125%. Transient = 1000% peak current for 10ms.

L. Maximum Output-Voltage Transient Excursions from Rated Value:

1. 4% with 50ms recovery from 100% load step for 3phase systems > 20kW.
2. 6% with 50ms recovery from 100% load step for 3phase systems < 20kW.

M. Input Power Factor: 0.95 - 0.99 lagging at rated load.

2.4 UPS SYSTEMS
   A. Electronic Equipment: Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, and system controls.
   B. Enclosures: Comply with NEMA 250, Type 1, unless otherwise indicated.
   C. Control Assemblies: Mount on modular plug-ins, readily accessible for maintenance.
   D. Input surge withstand capability to protect rectifier-charger, inverter, controls, and output components: The UPS shall be in compliance with IEEE 587 (ANSI C62.41), category A & B (6kV).

2.5 RECTIFIER-CHARGER
   A. Capacity: Adequate to supply the inverter during rated full output load conditions and simultaneously recharge the battery from fully discharged condition to 95 percent of full charge within 10 times the rated discharge time for duration of supply under battery power at full load.
   B. Output Ripple: Limited to less than 0.5 percent of rated current peak-to-peak.
   C. Control Circuits: Immune to frequency variations within rated frequency ranges of normal and emergency power sources. Rectifier restarts and walks in and gradually assumes the battery recharge and inverter loads. Adjustable up to 30 seconds and is visibly displayed on the front panel.
   D. Battery Float-Charging Conditions: Comply with battery manufacturer's written instructions for battery terminal voltage and charging current required for maximum battery life.

2.6 INVERTER
   A. Description: Pulse-width modulated, utilizing IGBT’s with sinusoidal output.

2.7 STATIC BYPASS TRANSFER SWITCH
   A. Description: The static bypass shall consist of a fully rated, continuous duty, naturally commutated static switch for high-speed transfers.
   B. Switch Rating: Continuous duty at the rated full UPS load current, minimum.

2.8 BATTERY
   A. Description: Valve-regulated-lead-acid (VRLA) units factory assembled in an isolated compartment of UPS cabinet or in an external battery cabinet complete with battery disconnect switch. Batteries shall be arranged for drawout removal from cabinet for testing and inspecting.
   B. Battery Capacity/Run Time: ______________. [edit per project requirements]
   C. Special Environmental Conditions: ______________. [edit per project requirements]
   D. Battery Bus Configuration: _____________. [edit per project requirements]
E. Seismic-Restraint Design: Battery racks, cabinets, assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) shall be designed and fabricated to withstand static and seismic forces based on the seismic zone where they are installed.

F. DC-rated circuit breaker in each battery cabinet to allow multiple battery strings to be serviced independently of each other; ensuring backup power is always available to the UPS. Circuit breaker features UVR trip auxiliaries for system EPO and UPS sensing of battery breaker.

G. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. UPS Manufacture OEM models.
2. C&D Technologies, Inc.
3. Enersys.
4. Northstar Battery.

2.9 MAINTENANCE BYPASS/ISOLATION SWITCH

A. Description: Manually operated switch or arrangement of switching devices with mechanically actuated contact mechanism arranged to route the flow of power to the load around the rectifier-charger, inverter, and static bypass transfer switch.

1. Switch shall be electrically and mechanically interlocked to prevent interrupting power to the load when switching to bypass mode.
2. Switch shall electrically isolate other UPS components to permit safe servicing.

B. Comply with NEMA PB 2 and UL 891.

C. Switch Rating: Continuous duty at rated full UPS load current.


E. Key interlock requires unlocking maintenance bypass/isolation switch before switching from normal position with key that is released only when the UPS is bypassed by the static bypass transfer switch. Lock is designed specifically for mechanical and electrical component interlocking.

2.10 CONTROLS AND INDICATIONS

A. Description: Group displays, indications, and basic system controls on a common control panel on front of UPS enclosure.

B. Minimum displays, indicating devices, and controls include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms include audible signals and visual displays.

C. Indications: Plain-language messages on a digital LCD. (edit list for project requirements)

1. Quantitative indications shall include the following:
   a. Input voltage, each phase, line to line.
   b. Input current, each phase, line to line.
c. Bypass input voltage, each phase, line to line.
d. Bypass input frequency.
e. System output voltage, each phase, line to line.
f. System output current, each phase.
g. System output frequency.
h. DC bus voltage.
i. Battery current and direction (charge/discharge).
j. Elapsed time discharging battery.
k. Time remaining on discharge.

2. Basic status condition indications shall include the following:
   a. Normal operation.
   b. Load-on bypass.
   c. Load-on battery.
   d. Inverter off.
   e. Alarm condition.

3. Alarm indications shall include the following:
   a. Bypass AC input overvoltage or undervoltage.
   b. Bypass AC input overfrequency or underfrequency.
   c. Bypass AC input and inverter out of synchronization.
   d. Bypass AC input wrong-phase rotation.
   e. Bypass AC input single-phase condition.
   f. Battery system alarm.
   g. Control power failure.
   h. Fan failure.
   i. UPS overload.
   j. Battery-charging control faulty.
   k. Input overvoltage or undervoltage.
   l. Input circuit breaker tripped.
   m. Input wrong-phase rotation.
   n. Approaching end of battery operation.
   o. Battery undervoltage shutdown.
   p. Maximum battery voltage.
   q. Inverter fuse blown.
   r. Inverter inductor overtemperature.
   s. Inverter overtemperature.
   t. Inverter output overvoltage or undervoltage.
   u. UPS overload shutdown.
   v. Inverter output contactor open.
   w. Inverter current limit.

4. Controls shall include the following:
   a. Inverter on-off.
   b. UPS start.
   c. Battery test.
   d. Alarm silence/reset.
   e. Output-voltage adjustment.

D. Dry-form "C" contacts shall be available for remote indication of the following conditions:
1. UPS on battery.
2. UPS on-line.
3. UPS load-on bypass.
4. UPS in alarm condition.
5. UPS off (maintenance bypass closed).

2.11 MONITORING/CONTROL BY REMOTE COMPUTER

A. Coordinate remote monitoring and control communication module package with the University’s SCADA network for successful transmission and remote readout of monitoring data and UPS Control. Connect remote monitoring communication module to the University’s SCADA network through appropriate network interface unit. The manufacturer shall wire between all communications capable devices within the equipment, including electronic meters with the same protocol and wire to a set of easily accessible terminal blocks.

B. Description: Communication module in unit control panel provides capability for remote monitoring of status, parameters, and alarms specified in "Controls and Indications" paragraphs. The remote computer and the connecting signal wiring are not included in this Section. Include the following features:

1. SCADA interface units for data transmission via Modbus TCP/IP.

2.12 EMERGENCY MODULE OFF

A. Emergency-Power-Off Switch: Capable of local operation by means of activation by red pushbutton under protective cover on UPS module control panel.

B. Provisions for a remote emergency power off function by means of activation by external dry contacts which completely removes power from the critical bus.

2.13 MAINTENANCE BYPASS/ISOLATION SWITCH CABINET

A. Description: Manually operated switch or arrangement of switching devices with mechanically actuated contact mechanism arranged to route the flow of power to the load around the rectifier-charger, inverter, and static bypass transfer switch.

1. Switch shall be electrically and mechanically interlocked to prevent interrupting power to the load when switching to bypass mode.
2. Switch shall electrically isolate other UPS components to permit safe servicing.

B. Switch Rating: Continuous duty at rated full UPS load current.

C. Mounting Provisions:

1. Matching cabinet for right or left side location as required with factory integrated interlocking scheme.
2. Wall mounted or free-standing enclosures as required with key interlocks and a solenoid key release unit or OEM provided equivalent as approved by the University.

D. Bypass Interlock requirements: Interlock scheme shall insure proper user operation of the systems without the risk of damage or load loss.
2.14 BATTERY MONITORING

A. BASIC BATTERY MONITORING: Subject to compliance with requirements, the UPS shall contain a battery management system which has the following features:

1. The battery management system shall provide battery time remaining while operating in normal mode and battery mode. Battery time available information shall be displayed real-time, even under changing load conditions. Upon commissioning, battery runtime information shall be available.

2. The battery management system shall automatically test the battery system to ensure that the battery is capable of providing greater than 80% of its rated capacity. Testing the batteries shall not jeopardize the operation of the critical load. Upon detection of the battery string(s) not capable of providing 80%, the UPS system will alarm that the battery needs attention/replacement. The battery test shall be able to detect the following:

   a. Open battery string
   b. Shorted battery string (current limit)
   c. Battery capacity (runtime) less than 80% of “new” battery capacity

B. COMPREHENSIVE BATTERY MONITORING: For external stationary battery plants, optional per/cell Battery Monitoring shall be available. Per/Cell battery monitoring will track and trend key performance metrics for each battery that includes the following:

   2. Cell Ohmic value (impedance).
   4. Optional ambient temperature.
   5. Optional string discharge current.

C. Battery Monitoring shall be wired and shall provide a web or client based user interface to configure and review systems settings, alerts, and reports through the SCADA network. Storage and management options shall be available that allow all installed systems to be managed from a single account.

2.15 SOURCE QUALITY CONTROL

A. Factory test complete UPS system before shipment. Use simulated battery testing. Include the following:

   1. Test and demonstration of all functions, controls, indicators, sensors, and protective devices.
   2. Full-load test.
   4. Overload test.
   5. Power failure test.

B. Report test results.
3.1 INSTALLATION

A. Equipment Mounting: Examine UPS system before installation. Reject equipment that is moisture damaged or physically damaged. Examine elements and surfaces to receive UPS for compliance with installation tolerances and other conditions affecting performance of the Work. Comply with requirements for installation as specified by supplier.

B. Maintain minimum clearances and workspace at equipment according to manufacturer’s written instructions and NFPA 70.

C. Connections: Interconnect system components. Make connections to supply and load all circuits according to manufacturer’s wiring diagrams unless otherwise indicated.

D. Grounding Separately Derived Systems: If not part of a listed power supply for a data-processing room, comply with NFPA 70 – 250 requirements.

E. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

G. Identify components and wiring according to Division 26 Section "Identification for Electrical Systems."

3.2 CONNECTIONS

A. Provide all communications wiring between remote metering and communication modules and the University’s SCADA system. Verify that each UPS address for microprocessor-communication packages corresponds to SCADA network requirements.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer’s Field Service: Engage a factory employed service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Comply with manufacturer’s written instructions.

2. Inspect interiors of enclosures, including the following:

   a. Integrity of mechanical and electrical connections.
   b. Component type and labeling verification.
   c. Ratings of installed components.

3. Test manual and automatic operational features and system protective and alarm functions.
4. Test communication of status and alarms to remote monitoring equipment.

5. OPTIONAL Provide load bank to be used during system startup by Manufacturer to verify the following:
   a. Transfer to and from bypass.
   b. Transfer to and from battery power.
   c. Operation of inverter with load for a minimum of 30 minutes.
   d. Verification of battery discharge. Record results.

C. The UPS system startup will be considered completed and accepted until the UPS passes all tests and inspections. Warranty term will begin following successful factory startup completion.

D. Record of Start up Tests and Inspections: Maintain and submit documentation of tests and inspections, including references to manufacturers’ written instructions and other test and inspection criteria. Include results of start up tests, inspections, and retests.

E. Prepare start up test and inspection reports, submit to NU Electric Shop.

3.4 DEMONSTRATION

A. Engage a factory-authorized representative to train the University’s maintenance personnel to adjust, operate, and maintain the UPS. Provide eight (8) hours of classroom and hands-on training.

END OF SECTION 26 3353
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes transfer switches rated 600 V and less, including the following:

1. Automatic Transfer Switches (ATS).
2. Closed Transition Transfer Switches (CTTS).

B. Related Sections include the following:


1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, accessories and catalog data sheets.

B. Shop Drawings: "Typical" drawings are not acceptable. Provide project specific drawings for each transfer switch. Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

1. Wiring Diagrams: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Qualification Data: For manufacturer.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Features and operating sequences, both automatic and manual.
2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.

B. Source Limitations: Obtain automatic transfer switches and bypass/isolation switches through one source from a single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with NEMA ICS 1.

E. Comply with NFPA 70.

F. Comply with NFPA 110.

G. Comply with UL 1008 unless requirements of these Specifications are stricter.

H. Comply with most current edition of the Northwestern University Design Standards.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store enclosed transfer switches indoors in clean, dry space with uniform temperature to prevent condensation. Protect from exposure to dirt, fumes, water, corrosive substances, and physical damage.

B. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers.

1.6 PROJECT CONDITIONS

A. (Delete This Paragraph If Not Required) [Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by The University or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify the University no fewer than [two] calendar weeks in advance of proposed interruption of electric service.

2. Indicate method of providing temporary electric service.

3. Do not proceed with interruption of electrical service without the University’s Chief Electrician’s written permission.

4. The University Lock-out/Tag-out procedures shall be used with Contractor controlled locks and tags.

5. Comply with NFPA 70E.]
B. Installation Pathway: Remove and replace building components and structures to provide pathway for moving transfer switches into place.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for transfer switches, including clearances between transfer switches and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:

1. Ambient Temperature: Not exceeding 40 deg C.

1.7 COORDINATION

A. Coordinate sensor-communication module package with the University’s SCADA system for successful transmission and remote readout of remote monitoring data specified in this Section.

B. Floor mounted switches: Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Sections.

1.8 WARRANTY

A. Comply with Division 1 requirements.

B. The automatic transfer switch shall be provided with a ten year warranty, covering all parts, labor, travel and expenses during the first two years, followed by seven years of replacement parts coverage. Warranty shall commence on startup. Warranty shall not be dependent upon customer purchase of additional equipment or preventive maintenance contracts.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide products by:

1. Contactor Transfer Switches:
   b. Or equal products when approved in writing by the University’s Chief Electrician:
      1) ASCO 7000 Series (Evanston).
      2) Caterpillar. (Evanston only)
      3) Cummins. (Evanston only)
      4) Kohler. (Evanston only)
2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

B. Transfer switches shall be seismic certified, capable of operating successfully after being subjected to a minimum IBC 200% g Earthquake Test. Testing shall be performed and verified by an independent, A2LA accredited, testing laboratory, in accordance with IBC 2006.

C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

1. A color, ¼ VGA minimum, graphical display shall be provided for viewing data and setting operational parameters. Parameters shall also be available for viewing remotely and limited control through a front accessible USB communications port with keypad.

2. All control components and wiring shall be front accessible. All control wires shall be multi-conductor minimum 18 gauge 600-volt SIS switchboard type point to point harness. All control wire terminations shall be identified with tubular sleeve-type markers.

3. The Controller shall provide high intensity LED’s for the following:
   a. Source Availability - Indicates the source voltage and frequency are within pre-set parameters.
   b. Source Connected - Indicates the source main contacts closed and the load being served from the source.
   c. XFER Inhibit - Indicates that the ATS is being inhibited from automatic operation to the unconnected source.
   d. Alarm: Indicates an alarm condition is active.
   e. TD Active: Indicates that a transfer switch time delay is actively timing.

4. For ease of navigation, the display shall include the following:
   a. Soft Keys – Change function based on user location in the menu structure.
   b. Dedicated Navigational Keys – Home, Scroll Up, End, Escape and Enter.
   c. Dedicated Pushbuttons for Alarm Reset, Test, Control and Information.

D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

E. Electrical Operation: Accomplish by a non-fused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.

F. The automatic transfer switch shall be capable of transferring successfully in either direction with 70% of rated voltage applied to the switch terminals.

(G Select Paragraph ‘G’ or ‘H’ Per Job Requirements, review with University’s Chief Electrician)

G. [Switches shall be four-pole as indicated on the drawings. A true four pole switch shall be supplied, with all four poles mounted on a common shaft. The entire fourth pole assembly, including contacts, arc chutes, etc. shall be identical to the other power poles. The fourth pole shall be switched simultaneously with, and by the same mechanism as, the main power poles. The short circuit rating of the fourth pole shall be identical to the]
ratings of the main power poles. The complete assembly shall be factory tested to ensure proper operation and compliance with the specifications requirements.

H. [Switches shall be three-pole as indicated on the drawings with Neutral Terminal solid and fully rated, unless otherwise indicated.]

I. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. **Limitation:** Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
2. **Switch Action:** Double throw; mechanically held in both directions.
3. **Contacts:** Silver composition or silver alloy for load-current switching. All automatic transfer-switch shall have separate arcing contacts.

J. Tested Fault-Current Closing and Withstand Ratings: The transfer switch shall be UL listed in accordance with UL 1008 for 3 and 30 cycle close and withstand ratings for duty imposed by protective devices at installation locations in Project under the fault conditions indicated. Switches that are not tested and labeled by UL for 3 and 30 cycle ratings are not acceptable. In accordance with UL-1008, after completion of the short time closing and withstand testing, the same sample shall successfully pass the Temperature Test and the Dielectric Voltage-Withstand Test to verify the ability of the ATS to carry full rated current after completing the short time tests. The minimum UL listed close and withstand ratings at 480 VAC shall be as follows:

<table>
<thead>
<tr>
<th>Size Amps</th>
<th>3 Cycle</th>
<th>30 Cycle</th>
<th>Limiting Fuses</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 – 400</td>
<td>42 Ka</td>
<td>30 Ka</td>
<td>200,000 a</td>
</tr>
<tr>
<td>600 – 800</td>
<td>65 Ka</td>
<td>42 Ka</td>
<td>200,000 a</td>
</tr>
<tr>
<td>1000 – 1200</td>
<td>85 Ka</td>
<td>65 Ka</td>
<td>200,000 a</td>
</tr>
<tr>
<td>1600 – 3000</td>
<td>100 Ka</td>
<td>85 Ka</td>
<td>200,000 a</td>
</tr>
</tbody>
</table>

K. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with annunciator and University SCADA system.

L. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Division 26 Section "Identification for Electrical Systems."

1. **Designated Terminals:** Pressure type, suitable for types and sizes of field wiring indicated.
2. **Power-Terminal Arrangement and Field-Wiring Space:** Suitable for top or bottom entrance of feeder conductors as indicated.
3. **Control Wiring:** Equipped with lugs suitable for connection to terminal strips.

M. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, or in a switchboard assembly in accordance with UL 891, unless otherwise indicated. Enclosures shall be designed to allow installation against wall or floor mounted. Cable access shall be from the front. Provide a side pull box where shown on drawings.

1. Enclosure shall be constructed so that personnel are protected from energized bypass-isolation components during automatic transfer switch maintenance.
2. Automatic transfer switch components shall be removable without disconnecting external source or load power conductors.
3. Finish: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal.
4. The switch shall be operable from a dead-front location.
5. Provide copies of wiring diagrams and maintenance instructions located on the inside of enclosure door in a permanent mounting sleeve designed to hold the data.

N. Switches shall be equipped with NEMA 2-hole compression type CU lugs. The compression lugs shall be furnished with the ATS and the UL listing of the switch shall not be compromised.

O. Communications Modules:
1. Provide a web server communications gateway to accommodate digital and analog I/O serial communications over fieldbus networks using other protocols, including Modbus-RTU. It shall also serve as pass-through gateway providing access to the ATS through the University's SCADA system.
2. The Controller shall be capable of supporting Modbus TCP/IP Ethernet 10/100MBit communications or Modbus RTU via an internally mounted and self powered communications card. Include an RJ45 network connector and USB port.

P. Power quality metering:
1. Comply with Section 26 2713 “Electricity Metering” requirements.

2.3 AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. The normal and emergency contacts shall be positively interlocked mechanically and electrically to prevent simultaneous closing. Main contacts shall be mechanically locked in position in both the normal and emergency positions without the use of hooks, latches, magnets, or springs, and shall be silver-tungsten alloy. Main contacts on all size switches shall be segmented, and shall have separate arcing contacts with magnetic blowouts for positive arc-quenching and maximum contact life.

C. Switching Arrangement: The automatic transfer switch shall be double throw, actuated by one or two electrical operators, momentarily energized and connected to the transfer mechanism by a simple over-center type linkage, providing inherent "quick-break", "quick-make" operation when operated electrically or manually.

2. Dual operator for Standby or Optional Load switches, and Closed Transition for [per project requirements] loads. The adjustable time delay between the opening of the closed contacts and the closing of the open contacts shall allow the loads to be demagnetized before transfer.

D. Manual Switch Operation: All open transition transfer switches shall be equipped with a safe manual operator designed to prevent injury to operating personnel. The manual operator shall provide the same contact to contact transfer speed as the electrical operator to prevent a flash-over from switching the main contacts slowly. Manual operation shall not require prior disconnection of electrical operators or control wiring, and shall be safe even if the electrical operator becomes energized during manual operation. The manual operator shall be external
type, operable through the door of the enclosure. Safe manual transfer shall be possible under all load conditions, either energized or non-energized. The external manual operator is not required on transfer switches equipped with a bypass switch.

E. Automatic Transfer-Switch Features:

1. Programmable Undervoltage and Frequency Sensing for Each Phase of Normal and Emergency Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 70 to 98 percent of nominal, and dropout voltage is adjustable from 72 to 100 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent. Over voltage to pick up at 102 to 110% and drop out at 100 to 108%. Over frequency sensing to pick up at 50.1 to 69.8 Hz and drop out at 50.0 to 69.7 Hz. Under frequency sensing to pick up at 45.0 to 59.9 Hz and drop out at 45.1 to 60.0 Hz (VFS1,2)
2. Contact to close on normal source failure to initiate engine start (CES).
3. Normal status relay (CS1A).
4. Emergency status relay (CS2A).
5. Bypass and transfer switch auxiliary contact in parallel with engine start to maintain start signal whenever load is connected to emergency source (CMES).
6. The controller shall monitor phase rotation of both sources and inhibit transfer if both sources are not the same phase rotation. Source rotation shall be field selectable as either ABC or CBA (PRR).
7. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for 3 seconds (TDES).
9. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 105 percent of nominal. Factory set for pickup at 95 percent (VFS2).
10. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 5 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored (TDPS).
11. Time delays to control transition time delay on transfer and re-transfer (TDNNP, TDNP). For dual operator and closed transition types only.
12. Test Switch: Simulate normal-source failure (XT1G).
13. Switch-Position LED Pilot Lights: (LT1, LT2) Indicate source to which load is connected (green for normal, red for emergency).
14. Bypass switch position: Green LED (LT16) to indicate bypass switch is in bypass to normal position, flashing when ATS is isolated. Red LED (LT17) to indicate bypass switch is in bypass to emergency position.
15. Provisions to accept customer supplied remote contact closure or 24 VDC signal to initiate load test (LTR).
   a. Normal Power Supervision: (LT3) Amber light with nameplate engraved "Normal Source Available."
17. Unassigned Auxiliary Contacts: Two normally closed, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac (CS1P, CS2P).
19. Unassigned Auxiliary Contacts: Two closed, single-pole, double-throw contacts when switch is bypassed to normal and emergency switch positions, rated 10 A at 240-VAC (CB1, CB2).
20. Provide additional elevator signals on switches connected to emergency equipment branch:
   a. Additional Form “C” contacts (two) to indicate ATS in Emergency position.
   b. Form “C” time delay contacts (two) that change state simultaneously 0-3600 seconds before transfer in either direction and revert 0-3600 seconds after transfer is completed.
21. Engine Shutdown Timer: Time delay adjustable from zero to sixty minutes, and factory set for five minutes. Timer shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source. The transfer switch cool-down timer shall be coordinated with any engine control cool-down timers to avoid excessive unloaded operation.
22. Engine-Generator Exerciser: The controller shall include a user configurable exerciser. Exerciser shall be configurable for daily, 7 day, 14 day or 28 day exercise periods, each with (7) programmable events. The exerciser shall also be configurable as a full, 365 day exerciser with up to 24 independent exercise events. Each event shall be configurable for Test with Load and Test without Load. Each event shall include user adjustable start time, date and test duration. All time and date settings shall be stored in non-volatile EEPROM memory. The controller shall include full programmability for daylight savings time.
23. All pilot lights shall be LED, push-to-test type.

2.4 CLOSED TRANSITION TRANSFER SWITCHES

A. Automatic Closed-Transition Transfer Switches: Include the following functions and characteristics:

1. Fully automatic make-before-break operation.
2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
3. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.
   a. Initiation occurs without active control of generator.
   b. Controls ensure that closed-transition load transfer closure occurs only when the 2 sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.
4. Failure of power source serving load initiates automatic break-before-make transfer.

B. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
C. Provide a safety signal (Dry contact outputs) for customer-connected alarm and remote breaker tripping through shunt trips on normal source circuit breakers to force the normal power feeder breaker to open in the case of a failed-closed transition.

D. The CTTS/BPS shall be UL listed in accordance with UL 1008.

2.5 BYPASS/ISOLATION SWITCHES

A. Comply with requirements for Level 1 equipment according to NFPA 110.

B. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. The bypass isolation switch shall provide a safe and convenient means of manually bypassing and isolating the automatic transfer switch, regardless of the condition of position of the automatic transfer switch. The bypass isolation switch shall have the ability to be used as an emergency backup system in the event of a transfer switch failure. Include the following features for each combined automatic transfer switch and bypass/isolation switch:

1. The bypass switch shall be load break design. Bypassing shall be by means of a single, externally operated handle. This handle shall allow direct, one step bypass to either Source 1 or Source 2, regardless of the position of the automatic transfer switch. The bypass isolation switch shall be purely mechanical, and bypass operation shall not be dependent upon any electrical device or interlocks for safety purposes or proper sequencing.

2. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. While isolated, interlocks prevent transfer-switch operation, except for testing or maintenance.

3. Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations.

4. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.

5. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.

6. Operability: Constructed so load bypass and transfer-switch isolation can be performed by 1 person in no more than 2 operations in 15 seconds or less.

7. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.

8. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.

9. Installation: Enclosure requires front and side access or front and rear as shown on drawings.

C. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

2.6 SOURCE QUALITY CONTROL

A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for
compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - EXECUTION

3.1 INSTALLATION
A. Floor-Mounting Switch: Anchor to floor by bolting.
   1. Concrete Bases: 4 inches (100 mm) high (Evanston: 6 inches high east of Sheridan Rd.), reinforced, with chamfered edges. Extend base no more than 4 inches (100 mm) in all directions beyond the maximum dimensions of switch, unless otherwise indicated. Concrete, reinforcement, and formwork requirements are specified in Division 3 Sections.

B. Wall mounted Switch: Do not attach directly to walls or structural surfaces. Attach switch to the vertical finished or structural surface behind the switch on channels such as “Unistrut”.

C. Identify components according to Division 26 Section "Identification for Electrical Systems."

D. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

E. List of all factory settings of relays, timers, etc; provide relay and timer settings and calibration instructions, laminated, and attached to door.

3.2 CONNECTIONS
A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes and wire counts at no additional cost to The University if necessary to accommodate required wiring.
   1. Provide all wiring between transfer switches and elevator controllers to insure emergency operation.
   2. Provide all wiring between closed transition transfer switches and shunt trip circuit breakers to insure proper operation.
   3. Provide all necessary wiring between all transfer switches and generator(s) to insure proper operation.
   4. Provide all communications wiring between remote metering and communication modules and the University’s SCADA system.

B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 IDENTIFICATION
A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."
B. Nameplates: Label each Transfer Switch with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare and submit test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.
2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
   a. Check for electrical continuity of circuits and for short circuits.
   b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
   c. Verify that manual transfer warnings are properly placed.
   d. Perform manual transfer operation.
5. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
   a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
   b. Simulate loss of phase-to-ground voltage for each phase of normal source.
   c. Verify time-delay settings.
   d. Verify pickup and dropout voltages by data readout or inspection of control settings.
   e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
   f. Perform contact-resistance test across main contacts and correct values exceeding 500 micro-ohms and values for 1 pole deviating by more than 50 percent from other poles.
   g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
6. Provide load bank testing of transfer switches installed in Level 1 emergency power systems prior to connecting building load.
7. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
   a. Verify grounding connections and locations and ratings of sensors.

B. Coordinate tests with tests of generator and run them concurrently.
C. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

D. Remove and replace malfunctioning units and retest as specified above.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train the University's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below. Training shall consist of a minimum of two, complete 8-hour training sessions.

B. Coordinate this training with that for generator equipment.

END OF SECTION 26 3600
SECTION 26 4313 – SURGE PROTECTIVE DEVICES FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes field-mounted SPD for installation on new and existing low-voltage (120 to 480 V) power distribution equipment.

B. Related Sections:

1. Division 26 Section "Low Voltage Electrical Power Conductors and Cables".
2. Division 26 Section "Grounding and Bonding for Electrical Systems".

1.3 DEFINITIONS


B. SPD: Surge Protective Device(s), both singular and plural.

C. SVR: Suppressed voltage rating.

D. TVSS: Transient voltage surge suppressor(s), both singular and plural; also, transient voltage surge suppression.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating weights, electrical characteristics, furnished specialties, and accessories.

B. Verification that all SPD are UL tested and labeled with 20kA (In) nominal discharge rating for compliance to UL96A Lightning Protection Master Label and NFPA 780.

1.5 INFORMATIONAL SUBMITTALS

A. Product Certificates: For SPD devices, from manufacturer.

B. Field quality-control reports.

C. Warranties: Sample of special warranties.
1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For SPD devices to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Replaceable Protection Modules: One for each SPD provided.

1.8 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by UL and marked for intended location and application.

B. Comply with IEEE C62.41.2 and test devices according to IEEE C62.45.

C. Comply with NFPA 780.

D. Comply with NEMA LS 1.

E. Comply with UL 1449 and UL 1283 (Type 2 only).

F. Comply with NFPA 70.

G. Comply with FM Global requirements.

H. Comply with most current edition of the Northwestern University Design Standards.

1.9 PROJECT CONDITIONS

A. (Delete This Paragraph If Not Required) [Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by the University or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify the University’s Chief Electrician no fewer than ten (10) business days in advance of proposed electrical service interruptions.

2. Indicate method of providing temporary utilities.

3. Do not proceed with interruption of electrical service without the University’s Chief Electrician’s written permission.

4. The University Lock-out/Tag-out procedures shall be used with Contractor controlled locks and tags.

5. Comply with NFPA 70E.]

B. Service Conditions: Rate SPD devices for continuous operation under the following conditions unless otherwise indicated:

1. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.
2. Operating Temperature: 30 to 120 deg F (0 to 50 deg C).
3. Humidity: 0 to 85 percent, non-condensing.

1.10 COORDINATION

A. Coordinate location of field-mounted SPD devices to allow adequate clearances for maintenance, minimum 36” in front and 12” from centerline.

1.11 WARRANTY

A. Comply with Division 1 requirements.

B. Special Warranty: Manufacturer’s standard form in which manufacturer agrees to repair or replace components of surge suppressors that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Ten years from date of Beneficial Occupancy.

PART 2 - PRODUCTS

2.1 SERVICE ENTRANCE and TRANSFER SWITCH SUPPRESSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2. Eaton Electrical Inc.
3. Siemens Industry Inc.

B. Surge Protection Devices Installed in Existing Service Entrance Substations:

1. Type 1, Complying with UL 1449, 3rd edition, with UL card.
2. SPD relying upon external or supplementary installed safety overcurrent protection do not meet the intent of this specification.
3. Fabrication using bolted compression lugs for internal wiring.
4. Arrangement with copper bus bars and for bolted connections to phase buses, neutral bus, and ground bus.
5. Provide a three pole circuit breaker as a dedicated disconnecting means.
6. LED indicator lights for power and protection status.
7. Audible alarm, with silencing switch, to indicate when protection has failed.
8. Form-C contacts rated at 5 Amp and 250-VAC, one normally open and one normally closed. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device.

C. Surge Protection Devices Installed in new Service Entrance Substations:

1. Type 1, Complying with UL 1449, 3rd edition, with UL card.
2. SPD relying upon external or supplementary installed safety overcurrent protection do not meet the intent of this specification.
3. Arranged for copper bus bar connections to phase buses, neutral bus, and ground bus.
4. A three pole circuit breaker for dedicated disconnecting means shall be provided in the switchgear.
5. LED indicator lights for power and protection status.
6. Audible alarm, with silencing switch, to indicate when protection has failed.
7. Form-C contacts rated at 5 Amp and 250-VAC, one normally open and one normally closed. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device.
8. Six-digit transient-event counter set to totalize transient surges.

D. Comply with UL 1283.
E. Minimum Surge Current Capacity Rating: 300 kA per phase.
F. Nominal discharge current (In): 20 kA.
G. Short circuit current rating (SCCR): 200 kA.
H. Maximum Continuous Operating Voltage (MCOV):
   1. 480/277 V: 320 V.
   2. 208/120 V: 150 V.
I. UL 1449 VPR for grounded wye circuits with [480Y/277 V] [208Y/120 V], 3-phase, 4-wire circuits shall be as follows:
   1. Line to Neutral: [1200 V for 480Y/277 V] [700 V for 208Y/120 V].
   2. Line to Ground: [1200 V for 480Y/277 V] [700 V for 208Y/120 V].
   3. Neutral to Ground: [1200 V for 480Y/277 V] [700 V for 208Y/120 V].
   4. Line to Line: [2000 V for 480/277 V] [1200 V for 208/120 V].

2.2 DISTRIBUTION SWITCHBOARDS and PANELBOARD SUPPRESSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Current Technology Inc.
   2. Eaton Electrical Inc.
   3. Siemens Industry Inc.

B. Products shall be installed external to new or existing distribution and branch panel equipment. SPD must have the same or greater AIC, Interrupting, or Fault rating of the equipment the SPD is protecting.

C. Surge Protection Devices:
   1. Type 2, Comply with UL 1449, 3rd edition with UL card.
   2. Externally mounted.
   3. Short-circuit current rating complying with UL 1449, and matching or exceeding the equipment short-circuit rating and redundant suppression circuits; with individually fused metal-oxide varistors.
   4. SPD relying upon external or supplementary installed safety overcurrent protection do not meet the intent of this specification.
   5. Fabrication using bolted compression lugs for internal wiring.
7. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
8. LED indicator lights for power and protection status.
9. Audible alarm, with silencing switch, to indicate when protection has failed.
10. Form-C contacts rated at 5 Amp and 250-VAC, one normally open and one normally closed. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device.

D. Comply with UL 1283.

E. Minimum Surge Current Capacity Rating:
   1. LV switchgear, Switchboards, Distribution panels: minimum 200 kA.
   2. Branch Circuit Panelboards: minimum 100 kA.

F. Nominal discharge current (In): 20 kA.

G. Short circuit current rating (SCCR): 200 kA

H. Maximum Continuous Operating Voltage (MCOV):
   1. 480/277 V: 320 V.
   2. 208/120 V: 150 V.

I. UL 1449 VPR for grounded wye circuits with [480Y/277 V] [208Y/120 V], 3-phase, 4-wire circuits shall be as follows:
   1. Line to Neutral: [1200 V for 480Y/277 V] [700 V for 208Y/120 V].
   2. Line to Ground: [1200 V for 480Y/277 V] [700 V for 208Y/120 V].
   3. Neutral to Ground: [1200 V for 480Y/277 V] [700 V for 208Y/120 V].
   4. Line to Line: [2000 V for 480/277 V] [1200 V for 208/120 V].

2.3 ENCLOSURES

A. Indoor Enclosures: NEMA 250, Type 1.

B. Outdoor Enclosures: NEMA 250, Type 3R.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Type 1 SPD devices at service entrance Secondary Unit Substations shall be installed on the line side with ground lead bonded to service entrance ground.

B. Install Type 2 SPD devices for new or existing distribution switchgear, switchboards and panelboards externally with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
1. Provide a three pole circuit breaker as a dedicated disconnecting means for each SPD unless otherwise indicated. Disconnecting means shall occupy the first three spaces in existing equipment; adjust circuit-breaker positions to achieve shortest and straightest leads.

2. Use crimped connectors and splices only. Wire nuts are unacceptable.

C. Provide all communications wiring between remote alarm contacts and the University’s SCADA system.

3.2 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, “Surge Arresters, Low-Voltage Surge Protection Devices” Section. Certify compliance with test parameters.

2. After installing SPD devices but before electrical circuitry has been energized, test for compliance with requirements.

3. Complete startup checks according to manufacturer’s written instructions.

C. SPD device will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports, submit to NU Electric Shop.

3.3 STARTUP SERVICE

A. Do not energize or connect service entrance equipment, distribution equipment, or panelboards to their sources until SPD devices are installed and connected.

B. Do not perform insulation resistance tests of the distribution wiring equipment with the SPD installed. Disconnect before conducting insulation resistance tests, and reconnect immediately after the testing is over.

3.4 DEMONSTRATION

A. Train the University’s maintenance personnel to maintain SPD devices.

END OF SECTION 26 4313
SECTION 26 5100 - INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Interior solid-state luminaires that use LED technology.
   2. Emergency lighting units.
   3. Exit signs.
   4. Luminaire supports.

B. Related Sections:
   1. Section 26 2726 "Wiring Devices" for occupancy sensors and manual wall box dimmers.
   2. Section 26 0519 "Low Voltage Electrical Power Conductors and Cables" for wire and cabling.

1.3 SYSTEM DESCRIPTION

A. Catalog numbers indicated in the Luminaire Schedule are a design series reference and do not necessarily represent the exact catalog number, size, voltage, wattage, type of light bar, driver, finish trim, ceiling type, mounting hardware or special requirements as specified or as required by the particular installations. Provide complete luminaire to correspond with the features, accessories, number of LED's, wattage and/or size specified in the text description of each luminaire type. Additional features, accessories and options specified shall be included.

B. Provide all frames, supplementary support structures, hangers, spacers, stems, aligner canopies, auxiliary junction boxes and other hardware as required for a complete and proper installation. Recessed luminaires shall have frames that are compatible with the ceiling systems.

C. Luminaire voltage shall match the voltage of the circuit serving same.

1.4 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color-rendering index.

C. IP: International Protection or Ingress Protection Rating.
D. LED: Light-emitting diode.

E. LER: Luminaire efficacy rating.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting fixture, including lamp, reflector, and housing.

1.5 SUBMITTALS

A. Product Data: For each type of luminaire, arranged in order of luminaire designation. Include data on features, accessories, finishes, and the following:

1. Material and physical description of luminaire including dimensions.
2. Emergency lighting units including battery and charger.
4. Life, output (lumens, CCT, and CRI), Kelvin temperature, and energy-efficiency data for LED light bars.
5. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing & Calculation Guides, of each luminaire type. The adjustment factors shall be for light bars, drivers, and accessories identical to those indicated for the luminaire as applied in this Project.
   a. Testing Agency Certified Data: For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer. LM-79 and LM-80 data for solid state lighting.
   b. Manufacturer Certified Data: Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
6. Photometric data, certified by a qualified independent testing agency, in IESNA format, based on certified results of laboratory tests of each luminaire type, outfitted with light bars, drivers and accessories identical to those indicated for the luminaire as applied in the Project.
7. Low voltage transformers.
8. LED power supplies.
9. Types of LED’s, including manufacturer, wattage, and Color Rendering Index (CRI) and color temperature in degrees Kelvin (K).

B. Shop Drawings shall:

1. Show detail of nonstandard or custom luminaires.
2. Indicate dimensions, weights, method of field assembly, components, features and accessories.
3. For custom luminaires, modified luminaires or linear luminaires mounted in continuous rows, submit scaled drawings prepared by the manufacturer showing all details of construction, lengths in runs, pendant or power feed locations, accessories, finishes and lists of materials.
4. This Contractor shall provide the manufacturer with accurate field dimensions where required.
5. Include wiring diagrams, power and control wiring.
C. Wiring diagrams shall detail wiring for luminaires and differentiate between manufacturer installed and field installed wiring.

D. Product Certificates shall be signed by manufacturers of luminaires certifying that products comply with requirements.

E. Dimming Driver Compatibility Certificates shall be signed by the manufacturer of driver certifying that drivers are compatible with dimming systems and equipment with which they are used. Product Certificates signed by product manufacturer shall be provided for each type of driver for dimmer controlled luminaires.

F. Maintenance Data shall be provided for luminaires and equipment to include in emergency, operation and maintenance manuals specified in specifications section describing Operations and Maintenance Data.

G. Field quality control test reports.

H. Special Warranties specified in the Section.

I. Review of luminaire submittals which indicate voltage, mounting condition, or quantities shall not be considered to be approval of said voltage, mounting condition or quantities. This Contractor shall field verify voltage and actual mounting condition and method.

J. Product samples complete with housing, trim, specified lumen package, and 8' cord with plug for 120 V shall be submitted if requested.

1.6 CUSTOM LUMINAIRES

A. All custom luminaires require a prototype to be submitted prior to commencement of fabrication. The purpose of the prototype will be to review construction, LED placement within luminaire, LED type, optical assembly, finishes, etc. Modifications may be required as a result of prototype review. These modifications and others that do not materially affect the cost of the luminaire shall be incorporated at no additional cost to the University, Architect, Lighting Designer, or Engineer.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For lighting equipment and luminaires to include in emergency, operation, and maintenance manuals.

1. Provide a list of all arrays and drivers types used on Project; use ANSI and manufacturers' codes.

1.8 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Glass, Plastic Diffusers and Lenses: 10% or one dozen (whichever is less) of each type and rating installed. Furnish at least one of each type.

2. Globes and Guards: 5% of each type and rating installed. Furnish at least one of each type.
1.9  DELIVERY, STORAGE AND HANDLING

A. Deliver luminaires individually wrapped in factory fabricated fiberboard type containers.
B. Handle luminaires carefully to prevent breakage, denting and scouring of the luminaire finish.
C. Store product in a clean, dry space, protected from weather.

1.10  QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7.
B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to the Authorities Having Jurisdiction, and marked for intended use.
C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
D. Comply with most current edition of the Northwestern University Design Standards.
E. Comply with NFPA 70.
F. Designated manufacturers are listed to define the requirements for quality and function of the specified product.
G. Mockups: Provide interior luminaires for room or module mockups complete with power and control connections.
   1. Obtain Lighting Designer’s and Architect’s approval of luminaires for mockups prior to starting installations.
   2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
   3. Remove mockups when directed. Luminaires may be reinstalled in the Work with approval from the University.
   4. Install luminaires for mockups with power and control connections.
   5. Mockups evaluated on the Project site may become part of the complete Work with the approval of the University, Lighting Designer and Architect if the mockup is undisturbed at the time of substantial completion.

1.11  COORDINATION

A. Coordinate layout and installation of luminaires with ceiling system and other construction that penetrates ceilings or is supported by them including mechanical system, fire suppression, and technology and partition assemblies.
B. Provide all frames, supplementary support structures, hangers, spacers, stems, aligner canopies, auxiliary junction boxes and other hardware as required for a complete and proper installation.
C. Recessed luminaires shall have frames that are compatible with the ceiling system indicated on the Architectural Drawings.

D. Coordination Meetings: This Contractor shall meet at least twice with the ceiling installer. Hold first meeting before submittal of shop drawings to coordinate each luminaire mounting condition with ceiling type. During second meeting, coordinate luminaire layout in each area. This Contractor shall meet at least twice with the mechanical systems installer prior to fabrication and installation of ductwork. Coordinate depth and location of all luminaires with ductwork, fire suppression, and technology in all areas.

1.12 WARRANTY

A. Comply with Division 1 requirements.

B. General Warranty: Special warranty specified in this Section shall not deprive the University of other Rights the University may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by this Contractor under requirements of the Contract Documents.

C. Special Warranty for LEDs’ and Drivers: Manufacturers standard form in which manufacturer of LED’s and drivers agrees to replace components that fails in materials or workmanship within specified warranty period.

1. LED arrays: 10 years from date of Beneficial Occupancy.
2. Drivers: 10 years from date of Beneficial Occupancy.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products as listed in the Lighting Fixture Schedule or comparable products approved in writing by the University.

2.2 GENERAL REQUIREMENTS FOR LUMINAires AND COMPONENTS

A. Recessed Luminaires: Comply with NEMA LE 4 for ceiling compatibility for recessed luminaires.

1. Chicago campus: Where applicable, City of Chicago environmental air marking (CCEA) for plenum installations.

B. Luminaires: Comply with UL 1598.

C. Metal Parts: Free of burrs, sharp corners and edges. Metal work shall be free of tool marks and dents and shall have accurate angles bent as sharply as compatible with the gauges of the required metal. Intersections and joints shall be formed true and of adequate strength and structural rigidity to prevent any distortion after assembly. All miters shall be in accurate alignment with abutting intersection members.
D. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging. Luminaires to be painted after fabrication. Finish ferrous mounting hardware and accessories to prevent corrosion and discoloration to adjacent materials.

E. Luminaire hardware to comply with the following material standards: For steel and aluminum luminaires, all screws, bolts, nuts and other fastening and latching hardware shall be cadmium or equivalent plated. For stainless steel luminaires, all hardware shall be stainless steel.

F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Safety devices shall be detachable if necessary and shall not interfere with luminaire performance, maintenance or the seating of any luminaire element. Safety device shall not be visible during normal luminaire operation and from normal viewing angles.

G. Luminaires provided shall have means for disconnection from power source during service, as required in NEC Article 410.

H. Reflecting Surfaces: Minimum reflectance as follows, unless indicated otherwise:
1. White Surfaces: 85%
2. Specular Surfaces: 90%
3. Diffusing Specular Surfaces: 75%

I. Reflector cones shall adhere to the following:
1. Cones shall provide a minimum of 50 degree cutoff to source and source image.
2. Plastic material shall not be used for reflector cones.
3. Cones shall not be permanently fastened to the housing and shall be removable without tools. Retention devices shall not deform the cone or be visible from normal viewing angles.
4. Trim shall be flush to ceiling without gaps or light leaks. Where the flange trim is separate from the cone, it shall have the same finish as the reflector cone.
5. Reflector cones shall be uniform gauge, not less than 0.032” thick, high purity aluminum Alcoa 3002 alloy. Cones shall be free from spin marks or other defects.
6. Manufacture cones using the Alzak® process. Refer to Luminaire Schedule for cone color and finish, i.e., specular or diffuse requirements.

J. Lenses, Covers, Diffusers and Globes:
1. Acrylic Lighting Diffusers: 100% virgin acrylic plastic. UV stabilized high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
   a. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.
   b. Lenses shall have uniform brightness throughout the entire visible area without LED pixelation.
2. Glass Globes: Annealed crystal glass unless otherwise indicated.

K. Adjustable luminaires shall have positive locking devices to fix aiming angle. Luminaires shall be capable of being relamped without adjusting aiming angle.
L. Each luminaire that has an array with a beam pattern or a spread lens that defines beam orientation shall contain locking devices to insure the orientation is not disturbed during array replacement or cleaning.

M. All luminaires and drivers shall operate within the temperature limits of their design and as specified by UL in the applications and mounting conditions specified.

N. Luminaires recessed in suspended ceilings where the space above the ceiling is either an air supply or return plenum shall conform to NEC Article 300-22.

O. Provide plaster frame for recessed luminaires mounted in other than T-bar ceilings. Verify mounting with architectural reflected ceiling plan before ordering luminaires.

P. Fixtures installed in “hard” ceilings shall have all connections accessible through the luminaire.

Q. Provide wire guards on all open strip type luminaires in unfinished spaces.

R. For weatherproof or vapor-tight installations, finishes of luminaires and accessories shall be a premium 5 stage TGIC polyester powder coat paint minimum 2.5 mils thick, applied to factory-assembled and -tested luminaires before shipping, so that the entire assembly is completely corrosion resistant for the service intended. Exterior finishes shall have an outdoor life expectancy of not less than 20 years without any visible rust or corrosion. Where aluminum parts come in contact with bronze or steel parts, apply a coating material to both surfaces to prevent corrosion.

S. Luminaires for use outdoors or in areas designated as damp locations shall be suitable gasketed to prevent the entrance of moisture. Provide approved wire mesh screens for ventilation openings. Dissimilar metals shall be separated by non-conductive material to prevent galvanic action.

T. Factory-Applied Labels: Comply with UL 1598. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when light bars are in place.

U. Luminaires shall be free of light leaks while providing sufficient ventilation of LED’s and drivers to provide the required photometric performance.

V. Luminaires shall hold LED arrays securely against normal vibration and maintenance handling.

2.3 LUMINAIRES

A. Housing shall be minimum code gauge steel construction painted after fabrication with high reflectance white paint unless otherwise indicated.

B. Shielding shall adhere to the following criteria:

1. Flat frosted diffuser shall be 100% virgin acrylic, pattern #12, and shall have matte finish on exterior side. Diffuser shall be of sufficient density to completely obscure LED image.
2. Flat clear lenses shall be injection molded 100% virgin acrylic.
3. Clear patterned lenses shall be injection molded 100% virgin acrylic, pattern #12.
4. Clear patterned lenses shall be polycarbonate, pattern #12.
5. Minimum thickness shall not be less than 0.125” with a minimum weight of 8 ounces per square foot.
C. Doorframes shall be supplied with concealed hinges and latches. Provide mitered corners with no gaps or light leaks.

2.4 EMERGENCY BATTERY PACK FOR LUMINAIREs [Evanston]

A. Manufacturers:

B. Internal Type: Self-contained, modular, battery-inverter unit, factory mounted within/top of luminaire body and compatible with driver. Comply with UL 924.
   1. Indicator light: Visible without opening luminaire or entering ceiling space. Indicator Light: LED indicates normal power on.
   2. Battery: Sealed, maintenance-free, nickel-cadmium type, sized for ninety (90) minutes of operation.
   4. Integral Self-Test: Factory-installed electronic device automatically initiates code required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.
   5. Universal Voltage input.

2.5 MESSAGE SIGNS

A. Description: Comply with UL 924; for sign colors, visibility, luminance and lettering size. Comply with Authorities Having Jurisdiction, State and Local Codes.

B. Coordinate with Division 28 requirements.

C. Electrical: Internally mounted, universal 120/277V transformer.

D. Internally Lighted Signs:
   1. Light bars for AC operation: LED, 70,000 hours minimum rated life.

E. Heavy gauge steel housing and stenciled faceplate with glass or thermoplastic color shield.
   1. Legend: See Luminaire Schedule.

2.6 LED LUMINAIREs AND DRIVERS

A. All Luminaires
   2. Comply with IES LM-80-08 Approved Method for electrical and photometric measurement of SSL product.
   3. Comply with In-Situ testing for more reliable results.
   4. LED’s shall be Restriction of Hazardous Substances Directive (RoHS) compliant.
   5. LED arrays shall be sealed, high performance, long life type; minimum 70% rated output at 50,000 hours. (L70)
   6. LED luminaires shall deliver a minimum of 80 lumens per watt.
a. LED’s shall be “Bin No. 1” quality.

7. Drivers shall be solid state and accept 120 through 277 VAC at 60 Hz input.
8. The LED light source shall be fully dimmable with use of compatible dimmers switch designated for low voltage loads.
9. LED color temperatures: [3000/3500/4000/other (requires approval)] as noted, +/- 275K.
10. Luminaires shall have internal thermal protection.
11. Luminaires shall not draw power in the off state. Luminaires with integral occupancy, motion, photo-controls, or individually addressable luminaires with external control and intelligence are exempt from this requirement. The power draw for such luminaires shall not exceed 0.5 watts when in the off state.
12. Color spatial uniformity shall be within .004 of CIE 1976 diagram.
13. Color maintenance over rated life shall be within .007 of CIE 1976.
14. Indoor luminaires shall have a minimum CRI of 85.
15. Lumenaria manufacturers shall adhere to device manufacturer guidelines, certification programs, and test procedures for thermal management
16. LED package(s)/module(s)/array(s) used in qualified luminaires shall deliver a minimum 70% of initial lumens, when installed in-situ, for a minimum of 50,000 hours.
17. Luminaires shall be fully accessible from below ceiling plane for changing drivers, power supplies and arrays.

B. Power Supplies and Drivers

1. Power Factor: 0.90 or higher
2. Maximum driver case temperature not to exceed driver manufacturer recommended in-situ operation.
3. Output operating frequency: 60Hz.
5. Total Harmonic Distortion Rating: 20% Maximum.
6. Meet electrical and thermal conditions as described in LM-80 Section 5.0.
7. Fully dimmable, 0 – 10 VDC standard.
9. Compatibility of dimming switches: Certified by manufacturer for use with individually specified luminaire and individually specified control components.

2.7 LED ARRAYS

A. All LED’s of the same type are to be provided by the same manufacturer.

B. Equip each luminaire with the proper LED array of the type shown or specified in the Luminaire Schedule

2.8 WIRING

A. No internal wiring shall be visible at normal viewing angles.

2.9 LUMINAIRE SUPPORT COMPONENTS

A. Single-Stem Hangers shall be 1/2-inch steel tubing with swivel ball fitting and ceiling canopy. Finish shall be the same as the luminaire.
B. Twin-Stem Hangers shall be two, 1/2-inch steel tubes with single canopy arranged to mount a single fixture. Finish shall be the same as the luminaire.

C. Rod Hangers shall be 3/16-inch minimum diameter, cadmium-plated threaded steel rod.

D. Wires shall be ASTM A 641/A 641M, Class 3, soft temper, zinc coated steel, 12 gauge.

E. Wires for humid spaces shall be ASTM A 580/A 580M, composition 302 or 304, annealed stainless steel, 12 gauge.

F. Aircraft Cable Support shall use cable, anchorages, and intermediate supports recommended by luminaire manufacturer.

G. Hangers for pendant industrial luminaires shall be heavy duty No. 8 jack chain with hangers, “S” hooks, mounting straps, and all required accessories for complete installation.

2.10 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with Authorities Having Jurisdiction.

1. Comply with City of Chicago Building Code requirements for Chicago campus.

B. [Evanston only: Eco-Smart brand LED exit sign.

1. AC only or battery backup as scheduled.
2. Universal mount canopy.
3. Green Letters on white or black, mirror or brushed nickel field as scheduled.
4. Directional chevrons as indicated, field configurable.
5. LED panel, 0.25 W.
6. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack with nickel metal hydride battery with self diagnostics.]

C. Internally Lighted Signs:

1. Products: Provide products as listed in the Lighting Fixture Schedule.
2. Steel Housing, 20 gauge (Chicago campus), white finish.
3. Glass or plastic faceplate.
4. Red Letters on white field.
5. Directional chevrons as indicated.
6. Field selectable full size arrow designations (Chicago campus).
7. Light bars: LED, 70,000 hours minimum rated lamp life.
   a. Individual LED modules shall not be visible.
8. Maximum power consumption: 5 watts.
9. AC powered signs shall be 120/277V input.
10. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.

   a. LED, 70,000 hours minimum rated lamp life.
   b. Battery: Two hour capacity sealed, maintenance-free, Ni Cad type, five year manufacturer warranty.
   c. Charger: Fully automatic, solid-state type with sealed transfer relay.
d. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects light bars from battery, and battery is automatically recharged and floated on charger.

e. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.

f. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

g. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.11 EMERGENCY LIGHTING UNITS

A. General Requirements for Emergency Lighting Units: Self-contained units complying with UL 924.

3. Flexible cord and plug connections shall not be permitted.
4. Battery: Sealed, maintenance-free, lead-acid type.
5. Charger: Fully automatic, solid-state type with sealed transfer relay.
6. Lamping: Tungsten Halogen (Chicago only) or LED (Evanston).
7. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
8. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
9. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
10. Wire Guard: Heavy-chrome-plated wire guard to protect lamp heads or units in areas where subject to physical damage.
11. Integral Time-Delay Relay: Holds unit on for fixed interval of 15 minutes when power is restored after an outage.
12. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.
13. Factory supplied molded plug and cord where indicated.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Luminaires:

1. Set level, plumb, and square with ceilings and walls, and secure according to manufacturers written instructions and approved submittal materials, unless otherwise indicated.
B. Temporary Lighting: If it is necessary, and approved by Architect, to use permanent luminaires for temporary lighting, install and energize the minimum number of luminaires necessary. When construction is sufficiently complete, remove the temporary luminaires, disassemble, clean thoroughly, and reinstall.

C. Remote Mounting of Drivers: Distance between the driver and fixture shall not exceed that recommended by manufacturer. Verify, with manufacturers, maximum distance between driver and luminaire.

D. Mounting height indicated from finished floor to bottom of pendant luminaire or to the center of the outlet box for wall mounted luminaires unless otherwise noted. Verify mounting heights with Architect and Lighting Designer.

E. Mounting height may also be indicated as the length of the pendant below finished ceiling.

F. Lay-in Ceiling Luminaire Supports: Use grid as a support element.
   
   1. Luminaires of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support luminaires independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees. In addition, provide slack earthquake safety wire hangers secured diagonally from opposite luminaire corners to structural members above suspended ceiling.

G. Suspended Luminaire Support:
   
   1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
   3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of luminaire chassis, including one at each end.
   4. Do not use grid as support for pendant luminaires. Connect support wires or rods to building structure.
   5. All power feeds shall originate from the same location/end of each run.
   6. Where pendants or rods are longer than 48”, brace to limit luminaire swinging.

H. Provide all necessary hanging or mounting devices and accessories for all luminaires. Verify the types needed for various ceiling conditions. Plaster rings shall be provided where required.

I. Verify weight and mounting method of all luminaires prior to ordering and provide suitable support. Coordinate with General Contractor for luminaires that require additional blocking or support. Luminaire mounting assemblies shall comply with all local seismic codes and regulations.

J. Metal decking shall not be pierced for luminaire support.

K. Refer to architectural reflected ceiling plans for coordination of luminaire locations with mechanical, fire protection, technology and fire safety equipment. Where conflicts occur, coordinate with Architect, Engineer and Lighting Designer prior to installing any of the Systems.

L. In accessible suspended ceilings, luminaire wiring connections, including equipment grounding conductor, is to be through use of 72-inch (maximum) flexible conduit from a rigidly supported junction box.

M. Wire per requirements of branch circuit installation. Properly ground each luminaire.
N. Luminaires located in recessed ceilings with a fire resistive rating of 1 hour or more shall be enclosed in an approved fire resistive rated box equal to that of the ceiling. Acoustical ceiling tiles are not acceptable.

O. Install luminaires with vent holes free of air blocking obstacles.

P. This Contractor shall be responsible for adjusting aperture flanges or rings on all recessed luminaires to be flush with the finished ceiling. Trim shall completely conceal ceiling opening.

Q. Brace suspended luminaires installed near ducts or other elements so that they do not swing into obstructions.

R. Wall mounted luminaires shall be supported from four-square outlet box plaster ring and from wall at non-feed end with two 1/4-inch toggle bolts for gypsum board walls or 1/4-inch bolts to pre-set inserts for concrete wall.

S. Luminaires shall not be secured to ductwork or other Systems.

T. Adjust variable position lampholders for proper lamp position prior to luminaire installation.

U. Connect wiring according to Section 26 0519 “Low-Voltage Electrical Power Conductors and Cables.”

3.2 DOWNLIGHT LUMINAIRES

A. Recessed Type in Accessible Ceilings: Mount in frames suitable for the ceiling with the recessed portion of the luminaire securely supported from the ceiling opening by use of a metal trim ring.

B. Recessed Type in Non-accessible Ceilings: As Specified for mounting in accessible ceilings, except provide access to wiring and driver through the ceiling opening for the luminaire.

3.3 LUMINAIRES

A. Recessed Type: Support luminaires independent of the ceiling suspension system. Provide four integral tabs (one at each corner) which rotate into position and lock on ceiling tees after luminaire is lifted into the ceiling cavity or provide four clips similar to Caddy #535. Provide mounting frames suitable for the ceiling type. In addition, provide slack earthquake safety wire hangers secured diagonally from opposite luminaire corners to structural members above suspended ceiling.

B. Wall Mounted Type: Support from four-square outlet box plaster ring and from wall at non-feed end with two ¼ inch toggle bolts for gypsum board walls or ¼ inch bolts to pre-set inserts for concrete wall.

C. If clearance above T-bar system is too restricted to “tip-in" luminaire, coordinate with acoustic ceiling installer by leaving one cross T-bar off until the cross T-bar shall be secured into its proper place. Luminaires installed in hidden-spline-type ceilings shall have supporting channels installed by Ceiling Contractor to adequately support the luminaire without providing additional hangers from the structural ceiling above the suspended ceiling.

D. Surface Mounted Type:
1. Where mounted on accessible ceilings, support from structural members above ceiling by means of hanger rods through ceiling or as approved.

2. Continuous Runs of Luminaires: Laser sight to insure luminaires are straight and true when sighting from end to end, regardless of irregularities in the ceiling. Where luminaires are so installed, omit ornamental ends between sections. All seams/joints shall be tightly fitted.

E. Pendant Mounted Type:

1. Provide strong back channel entire luminaire length unless luminaire is designed specifically to be self-supporting.

2. Where suspended below accessible ceiling, provide structural support at suspended ceiling level from structural members above ceiling. Do not run hanger rods through ceiling.

3. Continuous Runs of Luminaires: Laser sight to insure luminaires are straight and true when sighting from end to end, regardless of irregularities in the ceiling. Where luminaires are so installed, omit ornamental ends between sections. All seams/joints shall be tightly fitted.

4. All power feeds shall originate from the same location/end of each run.

F. Install luminaire diffusers only after construction work, painting and clean up are completed.

3.4 LED LUMINAIRES

A. Adhere to manufacturers installation guidelines regarding proper thermal management.

3.5 LIGHTING CONTROL

A. Provide branch circuiting in coordination with the requirements of Division 26 Wiring Device Section and as indicated.

B. Where Quantum lighting control panels are used to sweep after hours in open areas or classrooms, provide all necessary interconnecting wiring and control modules, and local override switches for after hours operation. Verify correct operation in presence of NU Electric Shop.

3.6 CLEANING AND ADJUSTING

A. Remove protective plastic covers from luminaires and luminaire diffusers only after construction work, painting and clean-up are completed. Remove, clean, and reinstall all dirty reflectors and diffusers.

B. Clean luminaires internally and externally after installation. Use methods and materials recommended by manufacturer for cleaning Alzak reflectors and other surfaces.

C. Make final adjustment of aimable luminaires and adjustable light settings under the direction of the Architect and/or Lighting Designer during a scheduled period of time prior to the completion of the Project, after normal business hours if required. Include all equipment and personnel expenses including overtime required for focusing.
D. Luminaires, reflectors, louvers and accessories which are damaged, blemished, or impregnated with fingerprints shall be replaced at this Contractor's expense. All finishes shall be unmarred upon Project completion.

3.7 IDENTIFICATION

A. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

3.8 FIELD QUALITY CONTROL

A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery/generator and retransfer to normal. Walk test and verify foot-candle levels meet Code with meter.

B. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

C. Inspect each installed luminaire for damage. Replace damaged luminaires and components.

D. Replace all inoperable LED arrays at the end of construction prior to University beneficial occupancy.

E. Advance Notice: Give dates and times for field tests.

F. Provide instruments to make and record test results.

G. Malfunctioning Luminaires and Components: Replace or repair, then retest. Repeat procedure until units operate properly.

3.9 ADJUSTING

A. Occupancy Adjustments: Within 12 months of date of Substantial Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Some of this Work may be required after dark.

1. Adjust aimable luminaires in the presence of Architect and University representative.

END OF SECTION 26 5100
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section provides general requirements for a complete and fully operational Exterior Lighting System including:

1. Exterior Luminaires
2. Accessories
3. Luminaire supports
4. Poles
5. LED Arrays
6. Controls
7. Standard Fixture Schedule

B. Related Sections:

1. Section 26 5100 "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of buildings.
2. Section 26 0519 "Low Voltage Electrical Power Conductors and Cables" for wire and cabling.

1.3 SYSTEM DESCRIPTION

A. Catalog numbers indicated in the Luminaire Schedule are a design series reference and do not necessarily represent the exact catalog number, size, voltage, wattage, type of LED, driver, finish trim, mounting hardware or special requirements as specified or as required by the particular installations. Provide complete luminaire to correspond with the features, accessories, number of LED’s, wattage and/or size specified in the text description of each luminaire type. Additional features, accessories and options specified shall be included.

B. Luminaire voltage shall match the voltage of the circuit serving same.

1.4 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color-rendering index.

C. LER: Luminaire efficacy rating.
D. Luminaire: Complete lighting fixture, LED arrays, including driver housing.
E. Pole: Luminaire support structure, including tower used for large area illumination.
F. Standard: Same definition as “Pole” above.

1.5 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

A. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied as stated in AASHTO LTS-4-M.
B. Live Load: Single load of 500 lbf, distributed as stated in AASHTO LTS-4-M.
C. Ice Load: Load of 3 lbf/sq. ft., applied as stated in AASHTO LTS-4-M Ice Load Map.
D. Wind Load: Pressure of wind on pole and luminaire and banners and banner arms, calculated and applied as stated in AASHTO LTS-4-M.

1. Basic wind speed of calculating wind load for poles 50 feet (15 M) high or less is 90 mph.
   a. Wind Importance Factor: 1.3.
   c. Wind induced vibration.

1.6 SUBMITTALS

A. The authorized manufacturer’s representative for the Project area shall prepare Submittals for each luminaire type. In addition to the luminaire Submittals, a list shall be provided identifying the manufacturer representative for each luminaire type. Provide manufacturers’ names, addresses, and telephone numbers. Requests for prior approval shall also include this information. Submittals or requests for prior approval without this information will be rejected.

B. Product Data shall indicate that luminaire, LED arrays, and drivers fully comply with Contract Documents. Data shall be submitted for each type of luminaire indicated, arranged in order of luminaire designation. For standard catalog luminaires provide original product catalog sheets indicating data on features, accessories, finishes, and the following:

1. Materials and dimensions of luminaires.
2. Photometric data, in IESNA format, based on certified results of laboratory tests of each luminaire type, outfitted with LED arrays, drivers and accessories identical to those indicated for the luminaire as applied in the Project.
   a. Photometric data shall be certified by a qualified independent testing agency.
   b. Foot-candle map including existing fixtures’ contributions

3. Low voltage transformers.
4. LED power supplies.
5. Types of LED’s, including manufacturer, wattage, and Color Rendering Index (CRI) and color temperature in degrees Kelvin (K).

C. Shop Drawings shall:
1. Show details of nonstandard or custom luminaires.
2. Indicate dimensions, weights, method of field assembly, components, features, and accessories.
3. This Contractor shall provide the manufacturer with accurate field dimensions where required.
4. Include wiring diagrams, power and control wiring.

D. Wiring Diagrams shall detail wiring for luminaires and differentiate between manufacturer-installed and field-installed wiring.

E. Product Certificates shall be signed by manufacturers of luminaires certifying that products comply with requirements.

F. Maintenance Data shall be provided for luminaires and equipment to include in emergency, operation, and maintenance manuals Specified in Specifications Section describing Operations and Maintenance Data.

G. Field quality control test reports.

H. Special Warranties Specified in this Section.

I. Review of luminaire submittals which indicate voltage, mounting condition, or quantities shall not be considered to be approval of said voltage, mounting condition, or quantities. This Contractor shall field verify voltage and actual mounting condition and method.

J. Product samples complete with housing, trim, specified lumen package, and 8’ cord with plug for 120 V shall be submitted if requested.

K. Pole and Support Component Certificates: Signed by Manufacturers of poles, certifying that products are designed for indicated load requirements in AASHTO LTS-4-M and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations by a Professional Engineer.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For lighting equipment and luminaires to include in emergency, operation, and maintenance manuals.

1. Provide a list of all driver types used on Project; use ANSI and manufacturers’ codes.
2. Submit site map showing dimensioned locations all exterior lighting fixtures and poles with tags consistent with the University’s standard naming convention. Also show stubbed-out spare conduits, in-ground junction boxes, and underground sleeves. Indicate dimensioned locations of sleeve ends, conduits, and junction boxes from a permanent building or landscape feature. Circuit numbers for all loads shall be shown. Electronic files of site lighting maps be provided at Substantial Completion and submitted to the Electric Shop.

1.8 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Glass, Plastic Diffusers and Lenses: 10% or one dozen (whichever is less) of each type and rating installed. Furnish at least one of each type.
2. Globes and Guards: 5% of each type and rating installed. Furnish at least one of each type.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Package poles for shipping according to ASTM B 660.
B. Store poles on decay-resistant-treated skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.
C. Retain factory-applied pole wrappings on metal poles until right before pole installation. Handle with web fabric straps.

1.10 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7.
B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to Authorities Having Jurisdiction, and marked for intended use.
C. Comply with IESNA TM-15-11 and Addendum A for Backlight, Uplight, and Glare (BUG) ratings.
D. Comply with ANSI C7.3777.208 Standards for chromaticity of SSL products.
E. Comply with NFPA 70.
F. All luminaires shall bear a UL or ETL label.
H. Comply with most current edition of the Northwestern University Design Standards.
I. Designated manufacturers are listed in the Luminaire Schedule to define the requirements for quality and function of the specified product.

1.11 COORDINATION

A. Coordinate layout and installation of luminaires with plantings, paving, site walls, other site work elements, and existing luminaires.
B. Coordination Meetings: This Contractor shall meet at least twice with the sitework installer(s) and NU Chief Electrician (or his designee). Hold first meeting before submittal of shop drawings to coordinate each luminaire mounting condition and location. During second meeting, coordinate layout with other site components. Coordinate depth and location of all luminaire pole bases in all areas.
1.12 WARRANTY

A. Comply with Division 1 requirements.

B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.

1. Warranty Period for Fixture, including the LEDs, drivers and electrical components: Ten years from date of Beneficial Occupancy.

2. Warranty Period for housing paint and finish: Ten years from date of Beneficial Occupancy.

3. Warranty Period for Color Retention: Ten years from date of Beneficial Occupancy.

4. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less ten years from date of Beneficial Occupancy.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide one of the products indicated on Drawings and/or the Schedule at the end of this document.

2.2 GENERAL REQUIREMENTS FOR LUMINAIREs

A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to Authorities Having Jurisdiction.

B. Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.

C. Comply with IESNA TM-15-07 Luminaire Classification System for Outdoor Luminaires.

D. Metal Parts: Free of burrs and sharp corners and edges.

E. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use.

F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit easy replacement of drivers. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.

G. Exposed Hardware Material: Stainless steel.

H. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
I. Light Shields: Baffles made of metal or similar sturdy material, field installable and adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.

J. Optical assemblies: where specified, full cutoff with zero uplight, “dark sky” compliant. LED assemblies shall comply with IESNA BUG rating system.

K. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:
   1. White Surfaces: 85 percent.
   2. Specular Surfaces: 90 percent.
   3. Diffusing Specular Surfaces: 75 percent.

L. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses in luminaire doors.

M. Luminaires utilizing internal refractors are not allowed.

N. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM’s “Metal Finishes Manual for Architectural and Metal Products” for recommendations for applying and designating finishes.
   1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
   2. Finish: premium 5 stage TGIC polyester powder coat paint minimum 2.5 mils thick, applied to factory-assembled and -tested luminaires before shipping. Where indicated, match the finish process and color of pole or support materials.

O. Decorative Fixtures:
   1. Shall have minimum 74 lumens per watt.

P. Outdoor Wall Mounted Area Luminaires
   1. Shall have minimum 90 lumens per watt.
   2. No more than 48% of the total luminaire output shall be within the forward 60-80º zone.
   3. No more than 3% of the total luminaire output shall be in the forward 80-90º zone.
   4. No light at or above horizontal 90-180º zone.

Q. Canopy Luminaires
   1. Shall have minimum 100 lumens per watt.
   2. At least 30% of total luminaire output shall be within the 40-60º zone.
   3. No more than 20% of total luminaire output shall be above the 80º zone.

2.3 LED DRIVERS AND ARRAYS

A. UL 1598 listing.

B. LED arrays shall have LED’s that produce minimum 80 lumens/watt @ 525mA.
1. Lumen Depreciation Data: maintain greater than 95% lumen maintenance at 60,000 hours per IES TM-21.

2. LED color: neutral white, 4000 deg K, minimum CRI of 70, or as scheduled on the drawings.

C. LED arrays shall have an IP66 enclosure rating.

D. Driver + LED Life Rating not less than 100,000 hours.

E. Power supply / driver shall be field replaceable by means quick-disconnect connectors and easy access mounting hardware.

F. Drives shall accept 120 – 277 volts or 480 volts, 60 Hz.

G. Power Factor > 0.9@ full load.

H. THD < 20% @ full load.

I. Surge protection: 10kA/10kV per ANSI/IEEE C136.2-2014

J. The housing shall have an integral thermal management system with extruded aluminum radiation fins and lateral airways for passive cooling, no devices using moving parts are permitted.

K. Minimum starting temperature: minus 30 deg C, 40 deg C ambient.


M. Comply with In-Situ testing for more reliable results.

N. LED’s shall be Restriction of Hazardous Substances Directive (RoHS) compliant.

2.4 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

A. Comply with UL 773 or UL 773A.

B. Compatible with 7 – pin socket.

C. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc and off at 4.5 to 10 fc with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.

1. Adjustable window slide for adjusting on-off set points.

2.5 GENERAL REQUIREMENTS FOR POLES AND SUPPORT COMPONENTS

A. Structural Characteristics: Comply with AASHTO LTS-4-M.

1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in "Structural Analysis Criteria for Pole Selection" Article, with a gust factor of 1.3.
2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.

B. Luminaire Attachment Provisions: Comply with luminaire manufacturers’ mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
   1. Materials: Shall not cause galvanic action at contact points.
   3. Anchor-Bolt Template: Plywood or steel.

D. Handhole: Minimum clear opening of 2-1/2 by 5 inches with cover secured by stainless-steel captive screws.

E. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 3 Concrete Sections.

2.6 ALUMINUM POLES

A. Poles: Seamless, extruded structural tube complying with ASTM B 429/B 429M, Aluminum Alloy 6063-T6, unless noted otherwise, and access handhole in pole wall.
   1. Shape: Refer to Luminaire Schedule or shall match existing site poles.

B. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

C. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Section 26 0526 “Grounding and Bonding for Electrical Systems,” listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

D. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, and then bolted together with stainless-steel bolts.
   1. Tapered oval cross section, with straight tubular end section to accommodate luminaire.
   2. Finish: Match pole and luminaire material and finish.

E. Aluminum Finish: Comply with NAAMM’s “Metal Finishes Manual for Architectural and Metal Products” for recommendations for applying and designating finishes.
   1. Finish designations prefixed by “AA”, comply with the system established by the Aluminum Association for designating aluminum finishes.
   2. Finish: Premium five (5) stage TGIC polyester powder coat paint.
      a. Color: As selected by Architect from manufacturer's full range or to match existing adjacent poles.
2.7 POLE ACCESSORIES

A. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.

B. Fusing: One in each ungrounded power supply conductor. Voltage and current ratings as recommended by driver manufacturer. Fuseholders shall be completely waterproof and shall grip the fuse in the load side section when opened. The circuit shall be fused in the base of the pole and accessible through the handhole.

C. Banner Arms: Use shall be approved by NU Chief Electrician. Coordinate with manufacturer for maximum banner size limitations to avoid banner arm or pole failure. Banner arms shall be break-away type designed to fail before over stressing the pole.

D. Wind Mitigation Devices: Provide in areas of consistent, high, uneven winds.

E. Duplex Receptacle: In central areas of congregation, provide a NEMA 5-20R Duplex Receptacle in a weatherproof assembly complying with Section 26 2726 "Wiring Devices" for ground-fault circuit-interrupter (GFCI) type.

   1. Recessed, nonmetallic polycarbonate plastic or reinforced fiberglass, weatherproof in use, cover, color to match pole, with cord opening, that when mounted results in NEMA 250, Type 3R enclosure mounted 36” above finished grade. With lockable hasp and latch that complies with OSHA lockout and tag-out requirements.
   2. Where noted, provide minimum 1800-W transformer, 120V secondary, protected by replaceable fuses, mounted behind access cover.

F. Outdoor Wireless Controls: Where noted, provide wireless controls for remote monitoring, control, energy measurement and GPS mapping of pole mounted exterior luminaires.

   2. Basic Description: system consists of the following components:

      a. Node
      b. Gateway
      c. Modem
      d. Central Management System server

   3. Functional Performance: Gateway shall receive real time data from each Node. Transmitted messages shall include voltage, current, power factor, wattage, and hours of operation. Gateway and shall automatically transmit the status of each luminaire along with a unique code that identifies the transmitting station to the Central Management System (CMS) via modem.
   4. Provide network communications for the system according to manufacturer's written requirements. Coordinate remote communication module package with the University's SCADA system for successful transmission and remote readout of monitoring data and luminaire control.
   5. Furnish each luminaire with a 7-pin twist lock receptacle for connection to controls. Provide weather tight shorting cap when controls not in use.
PART 3 - EXECUTION

3.1 LUMINAIRE INSTALLATION

A. Fasten luminaire to indicated structural supports.
   1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

B. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.
   1. Provide house side shields where necessary to control spill light.

3.2 POLE INSTALLATION

A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on Drawings:
   1. Fire Hydrants and Storm Drainage Piping: 60 inches.
   3. Trees: 15 feet from tree trunk.

C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 3 Concrete Sections.

D. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
   1. Grout void between pole base and foundation. Use non-shrink or expanding concrete grout firmly packed to fill space.
   2. Install base covers unless otherwise indicated.
   3. Use a short piece of 1/2-inch diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

E. Raise and set poles using web fabric slings (not chain or cable).

3.3 BOLLARD AND INDIVIDUAL GROUND MOUNTED LUMINAIRES

A. Align units for optimum directional alignment of light distribution.

B. Install on concrete base with top 4 inches above finished grade or surface at bollard location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 3 Concrete Sections.
3.4 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 26 0533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.5 GROUNDING

A. Ground metal poles and support structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole unless otherwise indicated.
2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.
3. Provide a continuous grounding conductor in all exterior lighting circuits.

3.6 CONNECTIONS

A. [Outdoor Wireless Control Systems: Provide all communications wiring between remote metering and control modules and the University’s SCADA system. Verify that each luminaires' address for communication packages corresponds to data network requirements.]

3.7 FIELD QUALITY CONTROL

A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.

B. Replace all burned out or inoperative LED arrays at the end of Construction prior to University occupancy.

C. Advance Notice: Give dates and times for field tests.

D. Provide instruments to make and record test results.

E. Test as follows:

1. Verify proper operation, switching and phasing of each luminaire after installation.
2. Emergency Lighting: Interrupt electrical supply to demonstrate proper operation. Verify normal transfer to generator and retransfer to normal.
3. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to the lighting system, retest to demonstrate compliance with standards.

F. Malfunctioning Luminaires and Components: Replace or repair, then retest. Repeat procedure until units operate properly.

G. Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.
1. Verify operation of photoelectric controls.
2. [Verify operation of wireless controls, test send and receive data/commands between luminaires and CMS.]

H. Illumination Tests:

1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IESNA testing guide(s):
   
   a. IESNA LM-64, "Photometric Measurements of Parking Areas."
   b. IESNA LM-72, "Directional Positioning of Photometric Data."
I. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards. Submit Electronic files of site lighting maps to the Electric Shop.

Northwestern University Standard Fixture Schedule

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Volt</th>
<th>Lamp</th>
<th>Fixture Watts</th>
<th>Manufacturer</th>
<th>Series</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Pole Four inch round extruded 6061-T6 AL pole with 4-1/2” x 10” maintenance opening 25-1/4” from the bottom of the anchor plate with receptacle—in-door option, duplex 15A-120V GFI receptacle with lockable W-I-U cast AL door. Black textured polyester powder coat finish.</td>
<td>__</td>
<td>__</td>
<td>__</td>
<td>Philips - Lumec</td>
<td>RA61U – 12 – FS1 – GFI – M · BKTX</td>
</tr>
</tbody>
</table>

END OF SECTION 26 5600