ELECTRICAL: WIRE, CABLE, AND TERMINATIONS

BASIS OF DESIGN

This section applies to the design and installation of wire and cable systems and terminations.

Design Criteria

Medium Voltage

Review and modify the attached guide specification as required to meet the project requirements.

Cable and wire procurement, especially for short lengths of interlocked armored cable (IAC), can take additional time. The Engineer shall include fair warning to the Contractor in the specifications.

Cables are subject to ambient temperatures of –20 to +40 ºC (0 to 105 ºF).

Low Voltage

All wiring shall be in raceway systems unless otherwise noted.

Refer to “Electrical: Raceways” section for IAC applications.

Refer to “Electrical: Raceways” section for metal-clad (MC) cable and armored cable (AC) applications.

Refer to other specification sections for signal and communication type cable and terminations.

Any low-voltage cable in air-handling spaces or plenums shall be specifically listed for use in such places (unless in enclosed raceways or conduit).

Design Evaluation

The following information is required to evaluate the design:

- **Programming**
  - Statement of design intent, including materials and terminating devices
- **Schematic Design Phase**
  - Description of overall distribution concept
  - Outline specifications
- **Design Development Phase**
  - Preliminary one-line diagram showing conductor and cable sizing

  - Preliminary plans showing distribution routing and cable schedules
  - Preliminary detail drawings showing connection hardware information
  - Draft specifications

- **Construction Documents Phase**
  - Complete one-line diagram showing conductor and cable sizing
  - Complete plans showing distribution routing and cable schedules
  - Complete detail drawings showing connection hardware information, protection methods, and grounding information
  - Complete specifications

Submittals

- For medium-voltage systems, refer to the attached guide specification, “Medium-Voltage Wire, Cable, and Terminations.”
- For low-voltage systems, submit industry standard requirements.

Products, Materials, and Equipment

Medium Voltage

Refer to the attached guide specification, “Medium-Voltage Wire, Cable, and Terminations.”

Low Voltage

Refer to the attached guide specification, “Wires and Cables (600 Volts and Below)”.

Power conductors shall be stranded copper, 98 percent conductivity. Number 12 AWG (American Wire Gauge) is the minimum conductor size. Number 12 and No. 10 shall be solid conductor for lighting and receptacle branch circuits, and stranded for motor and equipment circuits and wherever vibration is a consideration.

Insulation shall be THWN or XHHW (Also THHN when 1/O or smaller).

Conductor color code shall be per requirements in these standards.

Control wiring cable (600 volt) shall be in accordance with power conductors above, except that No. 14 AWG shall be permitted and all control wiring shall be stranded.

"Low voltage" and special cables shall be as specified in subsequent functional sections (e.g., communications, fire alarm, computerized system, television, etc.).

Splices (600 volt):

- Shall be solderless type only.
- Preinsulated "twist-on" type shall be permitted on solid conductor size No. 10 and smaller.
- Shall be hydraulic compression long-barrel type with application preformed insulated cover, heat-shrinkable tubing, or plastic insulated tape for all stranded conductors.
- For stranded conductors, provide terminations designed for use with stranded conductors.

Terminations (600 volt):

- Two-hole long-barrel compression lugs: 250 kcmil and above.
- Single-hole compression lug: below 250 kcmil.
- Conductors No. 12 and smaller: provide eye or forked-tongue compression lugs at bolted or screw connections; no lugs are required for compression-style terminal blocks.
- Cable ties: Nylon or equivalent, locking type. Use a torque-limiting tool for installing ties.

Control cable splices shall be preinsulated crimp pigtail or butt splice connectors.

Control cable terminations shall be locking spade, insulated, compression lugs.

Installation, Fabrication, and Construction

Medium Voltage

Refer to the attached guide specification, “Medium-Voltage Wire, Cable, and Terminations.”

Medium-voltage cable splices and connections are often placed in tunnels and manholes open to non-electrical workers; thus splices shall be provided with protective covers and junction boxes with protective cages. The Engineer shall investigate and work with UC Construction Management in designing appropriate worker protection barriers.

Conduits for medium-voltage installations are rigid steel in buildings and street crossings; schedule 40 polyvinyl chloride (PVC) in direct-buried or concrete-encased applications; and cable tray in tunnels. Medium-voltage cable shall not be direct buried.

Size cable junction boxes to allow future expansion of the cable system.

Low Voltage

Provide cable ties (limit torque on ties) in panelboards, cabinets, and other unconfined spaces. Group and lace wiring neatly, and do not tie to factory-installed wiring in equipment. Bundle and tag multi-pole circuits in laboratory surface metal raceway.

Branch circuits: Homeruns greater than 75 feet to the first outlet shall be No. 10 minimum. Use no mechanical means for pulling wires, and no lubricant except powdered soapstone or an approved substitute. Make no splices in homeruns. Do not combine wiring from separate raceway systems unless specifically permitted by the Engineer.

Terminate conductors so that conductor information is easily visible on at least one termination per feeder or within panel or switchboard pulling space.

Observe cable bend radius limitations and follow lug manufacturer's installation procedure.

Provide all control wire terminations with approved wire markers that mark the conductor with the terminal number for the wire.

Do not score the conductor when stripping insulation, and always pare or pencil when using a blade. Use of a stripping tool is preferable.

Secure and tighten all terminations in accordance with manufacturer's recommendations.

Remove unterminated wiring unless noted otherwise or specifically approved to remain. Consult with the Engineer for precise instructions.

Crimp terminations larger than 8 AWG shall be of the hexacentric type.

END OF DESIGN INFORMATION SECTION

GUIDE SPECIFICATION

The following specification is intended as a guide only The Engineer shall write the specifications to meet the project requirements in consultation with University of Cincinnati Construction Management (CM).

ELECTRICAL — MEDIUM-VOLTAGE WIRE, CABLE, AND TERMINATIONS

PART 1 GENERAL

1.01 DESCRIPTION

A. Purpose

1. This section covers medium-voltage cable and terminations for use in the University's primary and secondary power distribution systems.

1.02 QUALIFICATIONS

A. Approved manufacturers

1. 15-kV wire and cables.

1.03 REFERENCES

A. Applicable codes, standards, and references codes, regulations, and standards

1. National Electrical Testing Association (NETA).
2. National Fire Protection Association (NFPA).
3. National Electrical Code (NEC).
4. Association of Edison Illuminating Companies (AEIC) CS6-96 (ethylene propylene rubber).
5. Insulated Cable Engineers Associations (ICEA) S-68-516 (ethylene propylene rubber).
6. Institute of Electrical and Electronics Engineers (IEEE) STD 400-1991 (DC Testing).
7. IEEE STD 48.
8. Underwriters Laboratories (UL) 1072, for physical requirements for the armor.
9. UL 1008, Automatic Transfer Switches.
10. State and local codes and ordinances.

1.04 COORDINATION

A. Coordinate operation and maintenance training times with UC CM.

1.05 SUBMITTALS

A. General

1. Submittals shall be in accordance with Conditions of the Contract and specification sections under General Requirements.
2. Submit detailed maintenance manuals and drawings, which include catalog information indicating the complete electrical and mechanical characteristics.
3. Submit current manufacturer's AEIC prequalification data.
4. Submit dimensioned cross-sectional drawings (manufacturer's data sheets are acceptable).
5. Submit finished cable tests — manufacturer's certified test reports showing compliance with ICEA S-68-516, Part 3, and UL 1072 for physical requirements of the armor and all AEIC final tests, including x–y plots of corona discharge for the actual cable furnished.
6. Submit pulling calculations and plan for each medium-voltage cable length.
7. Submit data sheet on crimping tools to be used.
8. Submit for approval the résumés of the medium-voltage cable splicers. Qualifications should include certification, recent work history on similar splice type, and knowledge of safety standards for electrical workers.

1.06 OPERATION AND MAINTENANCE MANUALS

A. Operation and Maintenance (O&M) manuals shall be in accordance with Conditions of the Contract and specification sections under General Requirements.

B. Operation and Maintenance manuals shall include but not be limited to pull calculations and catalog information indicating complete electrical and mechanical characteristics.

C. Manufacturer's certified test reports.

D. Manufacturer's AEIC prequalification data.

1.07 MEETINGS

A. Pre-installation conference: The Contractor shall request a pre-installation conference with UC Construction Management and UC Facilities Management for projects with medium- and high-voltage work.

B. The Contractor shall attend meetings with UC CM and/or UC CM's Representative as required to resolve any installation or functional problems.

C. Within 1 month after the "Notice to Proceed," the Contractor shall schedule a meeting with UC CM representatives to review electrical identification requirements.

PART 2 PRODUCTS

2.01 GENERAL

A. These cable and terminations specifications are in accord with UC CM's policy to construct permanent installations with long life, maximum reliability, and safety. It is intended that the best available materials be used and new and better materials be adopted as they become available and are approved by UC CM.

2.02 MEDIUM-VOLTAGE WIRE AND CABLE

A. Material: Copper conductors of 98 percent conductivity shall be used, unless use is restricted by government agencies.

B. Primary voltage cable: Cable construction and installation raceways shall be specified in detail. Primary voltage shall be as follows:

1. 12.47 kV Service: 1/c – 15 kV ethylene-propylene rubber (EPR) shielded cable and PVC overall jacket. Minimum size of cable shall be 4/0. Jacket shall have surface ink printing indicating manufacturer, cable size, insulation type, and voltage rating. Each cable shall have extruded semiconducting polymeric layer covered with helically applied copper tape insulation shield. Copper shield shall have overlay. Insulation level shall be 133 percent EPR; conductor wire shall be copper. Lead cable is not acceptable.

2. 4160 volt service: 1/c – 5 kV EPR shielded cable and PVC overall jacket. Jacket shall have surface ink printing indicating manufacturer, cable size, insulation type, and voltage rating. Each cable shall have extruded semiconducting polymeric layer, covered with helically applied copper tape insulation shield. Copper tape shall have overlay. Each cable shall have EPR, 133 percent insulation level. Conductor wire shall be copper. Lead cable is not acceptable.

3. Cable installation details

   a. Cable pulling tension shall not exceed the smallest of following values:

      (1) Allowable tension on conductor as published by the manufacturer.

      (2) Allowable tension on pulling devices.

      (3) Allowable sidewall tension.

   b. Cable-pulling attachment must be to the conductor only, and devices should be staggered to prevent overtensioning of pulling device.

   c. Cable continuity and phase identification shall be checked and tagged, using 1-inch by 3-inch plastic tags. In manholes, cables shall be identified with wording issued by the University Project Manager and have tags installed where cables enter and leave the manhole. Phase positions at terminating equipment shall be Phase A-B-C left to right facing the front, or A-B-C front to back, A-B-C top to bottom. Phasing must be confirmed before placing cable system into operation.

   d. Flame-proofing: Cables in manholes, vaults, etc., shall be flame-proofed with pressure-sensitive applied flame-proof tape.

e. Primary voltage cables shall have overcurrent protection at the point where the cable receives its supply (may not apply to loop distribution with pad-mounted switches). Feeder run size reduction must be coordinated in regard to appropriate cable damage curves. In general, feeder run size reduction is prohibited unless approved by the University Project Manager.

f. Cable entering a building and/or run inside the building shall be installed in rigid galvanized steel conduit or UL approved equipment.

4. Cable joints and termination

   a. Cable joints and termination must be of the same rating as conductors. Provide fully shielded joints for each phase conductor.

   b. In underground structures (e.g., manholes), provide watertight, fully submersible joints and terminations. Under no circumstance shall cable joints be installed in raceways.

   c. In general, compression-type connector approved for the terminating device is the only acceptable method. "T" splicing is not allowed under any circumstance.

   d. Cable splicers: Before any cable splicer starts to work, submit to the University Project Manager the names of the cable splicers with proof that each splicer has 3 years' experience or more in splicing and terminating cables for the type and rating to be used. The Project Manager may require each splicer to make a dummy joint and termination in accordance with manufacturer's instructions. In addition, the Project Manager may submit the dummy joint or termination to an approved cable testing contractor who is a member of NETA for evaluation before work can proceed.

   e. Cable terminating kit: Ray-Chem is the only acceptable kit for terminating any medium-voltage cables. Any deviation must be approved by the University Project Manager.

5. Testing of medium-voltage terminations

   a. All primary distribution voltage cables shall be given a DC high potential test before all permanent connections are made.

   b. Cable continuity and phase identification must be checked. Cables shall not be subjected to more than one high potential test without approval of the University Project Manager. Successive test shall be at voltages per instruction from the University Project Manager.

   c. The DC potential test voltage to be applied shall be 80 percent of manufacturer's acceptance test voltage level, applied in incremental steps and for such duration as specified by the University Project Manager until the 80 percent value is reached; then the 80 percent value must be held for 15 minutes. The test voltage should be applied gradually during the first minute, with initial application being not greater than the rated voltage of the cable.

   d. During high potential tests, leakage current readings shall be taken at 30-second intervals during the first 2 minutes of the test and at 1-minute intervals during the remainder of the test. If after the first minute the leakage current increases, the University Project Manager may elect to stop the test. Further tests will be made at his/her discretion only. No test will be accepted while there is continual increase in leakage current throughout the test. The cable must withstand the specified high-voltage test without breakdown.

e. Where cable is being spliced or joined to old cable system, test must be approved by the University Architect before testing is performed. The condition of old cable shall be determined. New cable shall be tested before connecting.

f. Test record shall include the following:

(1) Complete identification of cable, including approximate length.

(2) High potential value, leakage current value, and time data.

(3) The approximate average cable temperature and humidity.

(4) High potential versus leakage current plot.

g. Cable shall not be energized until these tests and phasing are confirmed and approval is given by the University Project Manager.

PART 3 EXECUTION

3.01 REQUIREMENTS

A. General Installation

1. Identification

a. Reference section "Electrical: Wire, Cable and Terminations."

2. Installation

a. Only personnel qualified and experienced in this type of work shall make connections.

b. Cables shall be installed with care to avoid damage.

(1) Cables showing damage after installation shall be replaced.

(2) Rollers and spools shall be used in adequate numbers for pulling in cables.

(3) The tension limitations, sidewall pressure, and minimum bending radius as given by the cable manufacturer shall be observed.

c. Cable pulling

(1) In no case will strands be removed to attach pulling eyes.

(2) Tension is limited to 1,000 lbs using basket grips.

(3) Lubrication shall be as approved for the insulation and raceway material.

(4) Prior to pulling, calculations of pulling tension and sidewall pressure shall be submitted.

(5) A dynamometer shall be used and tension shall be recorded for all MV pulls.

(6) Use no mechanical means for pulling No. 8 and smaller AWG conductors.

d. Cable-pulling setups and operations shall be witnessed by UC Facilities Management and UC Construction Management.

e. Interlocked armored cable shall be pulled only when both the armor and conductors are gripped. Remove cable similarly.

f. All cable that leaves a tray shall be taped/wrapped with Scotch 77, MAC AP30, or Quelcor "Quelpyre" fireproofing tape.

B. Medium-voltage cable terminations

1. Phase-mark each conductor, secure conductors adequately, and observe cable bend radius limitations. Construction Management will identify the phase rotation convention.
2. System phase sequence is A-B-C.
3. Medium-voltage switch phase terminations shall be A-B-C left to right when facing the front of the switch.
4. Junction box phase terminations are A-B-C left to right.
5. Standard link box phase terminations are A-B-C left to right, top to bottom, front to back. Some existing link box phase terminations are not standard, especially on the normal and emergency power system.
6. UC Facilities Management will identify the phase designation of the existing primary distribution system conductors to which the Contractor is to make a connection.
   a. They will also check the Contractor's work to ensure the accuracy of the connections.
   b. The Contractor shall arrange with UC CM the times when the Contractor's services will be required, and under no circumstances shall the Contractor connect to the existing system without UC CM's knowledge.
   c. The proper connection of the wires and cables to other systems as specified is entirely the responsibility of the Contractor.
   d. In the event the connections cannot be made as specified, the Contractor shall make the necessary corrections at its own expense.
7. Install cable terminations per manufacturer's recommendations.
8. Medium-voltage cable splices shall be made only when absolutely necessary. When necessary, splices shall be made only by personnel qualified and experienced in this type of work.
9. Each high-voltage splice or connection shall be permanently labeled with the following information:
   a. Contract or project designation.
   b. Contractor doing work.
   c. Name of splicer and date.
10. Do not score the conductor when stripping insulation and always pare or pencil when using a blade. Use of a stripping tool is preferable.
11. All terminations shall be secure and tightened in accordance with the manufacturer's recommendations.

C. Mounting and electrical connections

1. Mounting and electrical connections shall be in accordance with the manufacturer's installation instructions.

2. Coordinate remote control and annunciation with UC CM.

D. Training

1. Provide operation and maintenance training for two 2-hour sessions of on-site training for a total of six maintenance personnel.

2. Include troubleshooting, repair, and maintenance manuals for each participant.

E. Testing

1. Provide factory field startup and testing services to assist the Electrical Testing Contractor (ETC).

END OF GUIDE SPECIFICATION SECTION

GUIDE SPECIFICATION

The following specification is intended as a guide only. The Engineer shall write the specifications to meet the project requirements in consultation with University of Cincinnati Construction Management (CM).

ELECTRICAL — SECTION 16120D - WIRES AND CABLES (600 VOLTS AND BELOW)

PART 1 GENERAL

A. General

1. Solid and stranded wire: All wire shall be copper. No solid wire shall be used unless provided as an integral part of a component by the manufacturer.
2. Minimum size for lighting and power branch circuits: No. 12 AWG.
   a. Wiring for special systems will be found in the specification section of that system.
3. Cords to portable equipment shall be type ST or SRDT containing an identified equipment ground wire.
4. Circuit wiring through ballast channels of fluorescent fixtures shall be 600-volt, 90 degrees C insulation.
5. General use insulation: NEC, 600-volt type THHN/THWN or XHHN. Do not use the 90 degrees C ampacity rating for XHHW wire unless terminations are rated for 90 degrees C.
6. Use XHHW wire for exterior and wet area applications.
7. Connections in No. 10 and smaller wire shall be made with threaded on plastic or nylon insulated connectors, or crimped-on copper sleeves insulated with plastic electrical tape. Hard insulated bakelite or ceramic connectors are prohibited. Joints in No. 8 and larger conductors shall be made with pressure-type mechanical connectors insulated with plastic electrical tape.
8. Color Coding:
   - 120/208 - 3Ph. 4W 277/480 - 3Ph. 4W
   - Phase A: Black Brown
   - Phase B: Red Orange
   - Phase C: Blue Yellow
   - Neutral: White Gray
   - Ground: Green Green/yellow trace

B. Installation

1. If lugs or connectors supplied with purchased components do not meet the requirements of the specifications, field purchase and install lugs or connectors that are designed for use with wire type being used.

END OF GUIDE SPECIFICATION SECTION