Basis of Design

This section applies to the design and installation relating to 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 interlock armored cable, can take additional time. The consultant shall include fair warning to the Contractor in the specifications.
- Cables are subject to ambient temperatures of –20º to +40º C (0 to 105º F).
- Connection points shall be provided in all electrical vaults and manholes to allow future facilities and other services to be connected to the primary distribution system.
- The following are typical medium voltage connections:

16G – Figure 1

*Manifold Junction Boxes*

16G – Figure 2

*Bolt-T Connectors*
Low Voltage

- All wiring shall be in raceway systems unless otherwise noted.
- Refer to “Electrical – Raceway” section for Interlocked Armored Cable (IAC) applications.
- Refer to “Electrical – Raceway” 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. Indicate the location of connections and types of termination to the primary distribution system. Preliminary detail drawings showing connection hardware information. Draft specifications.
- **Construction Document Phase**: Complete one-line diagram showing conductor and cable sizing. Complete plans showing distribution routing and cable schedules. Final details on location of connections and types of termination to the primary distribution system. Complete detail drawings showing connection hardware information, protection methods and grounding information. Complete specifications.

Submittals

- For medium voltage systems, refer to attached guide specification, MV.Wire, Cable and Terminations.
- For low voltage systems, submit standard industry requirements.

Products, Material and Equipment

**Medium Voltage**

- Refer to attached guide specification MV Wire, Cable, and Terminations.

**Low Voltage**

- Power conductors shall be stranded copper, 98% conductivity. Number 12 AWG is the minimum conductor size. #12 and #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 THWN or XHHW (Also THHN when 1/O or smaller)
- Conductor color code per requirements in Electrical – Identification section
- 600 volt control wiring cable shall be in accordance with power conductors above, except #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.)
- 600 volt splices shall be:
  1) Solderless type only
  2) Preinsulated “twist-on” type permitted on solid conductor size # 10 and smaller
3) Hydraulic compression long barrel type with application preformed insulated cover, heat shrinkable tubing or plastic insulated tape for all stranded conductors.

4) For stranded conductors provide terminations designed for use with stranded conductors.

- **600V terminations:**
  1) 2-hole long barrel compression lugs - 250 kcmil and above
  2) Single hole compression lug - Below 250 kcmil
  3) Conductors #12 and smaller: Provide eye or forked tongue compression lugs at bolted or screw connections; no lugs required for compression style terminal blocks.
  4) Cable ties: Nylon or equivalent, locking type. Use a torque limiting tool for installation of ties.

- Control cable splices shall be pre-insulated 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 MV 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 Consultant shall investigate and work with Engineering Services in designing appropriate worker protection barriers.
- Conduits for medium voltage installations are rigid steel in buildings and street crossings; schedule 40 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.
- Do not add link boxes for new medium voltage installations (13kV, 4.16kV, 2.4kV). Utilize cable junction boxes.
- Use 15kV rated air-insulated sectionalizing switches, cable junction boxes or existing link boxes for 13.8kV systems.

**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 first outlet shall be # 10 minimum.
- Do not use mechanical means for pulling wires. Use lubricants that do not clog conduits after use. Splices are not allowed in Homeruns.
- 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 which 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 8awg shall be of the hexacentric type.

END OF DESIGN GUIDE SECTION
GUIDE SPECIFICATION

The following specification is intended as a guide only. The Consultant shall write the specifications to meet the project requirements in consultation with the Owner.

ELECTRICAL – MV 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. Medium voltage 5 and 15kV wire and cables

a. 5 and 15kV single conductor: Pirelli, Aetna, and Okonite

b. 5 and 15kV armored cable: Pirelli, Aetna, and Okonite

(1) Service Wire for short lengths of interlock armored cable (< 500 feet)

c. All other manufacturers shall be approved during the design prior to bidding.

1.03 RELATED SECTIONS

A. The work under this section is subject to requirements of the Contract Documents, including the General Conditions, Supplemental Conditions, and sections under Division 1 General Requirements.

B. Electrical Identification

C. Inspection, Calibration and Testing

1.04 REFERENCES

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

1. National Electrical Testing Association – NETA


3. National Electrical Code - NEC

4. AEIC CS6-96 (ethylene propylene rubber)

5. ICEA S-93-639 (ethylene propylene rubber)
6. IEEE STD 400-1991 (DC Testing)
7. IEEE STD 48
8. UL 1072 for physical requirements for the armor
9. UL 1008 – Automatic Transfer Switches
10. State and local codes and ordinances

1.05 COORDINATION

A. Coordinate Operations and Maintenance training times with the University.

1.06 SUBMITTALS

A. General

1. Submittals shall be in accordance with Conditions of the Contract and Division 01 Specification Sections.

2. Submit detailed maintenance manuals and drawings, which include catalog information indicating the complete electrical and mechanical characteristics.

3. Submit current manufacturer’s AEIC pre-qualification 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 the “Safety Standards for Electrical Workers” (WAC 296-45).

1.07 OPERATIONS AND MAINTENANCE (O&M) MANUALS

A. Operations and Maintenance Manuals shall be in accordance with Conditions of the Contract and Division 01 Specification Sections.

B. Operations 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 Pre-qualification Data
1.08 MEETINGS

A. Pre-installation conference
   1. The Contractor shall request a pre-installation conference with the University’s Engineering Services and University’s Physical Plant High Voltage Shop for projects with medium and high voltage work.

B. Attend meetings with the Owner and/or Owner’s Representative as required to resolve any installation or functional problems.

C. Within 1 month after “Notice to Proceed,” schedule a meeting with UW Representatives to review electrical identification requirements.

PART 2 – PRODUCTS

2.01 GENERAL

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

2.02 MEDIUM VOLTAGE WIRE AND CABLE

A. The following shall apply to both 5kV and 15kV medium voltage power conductors used as single conductors or assembled into 3/c armored cable:

   1. Single conductors
      a. Conductors: Class B stranded, concentric, soft or annealed copper per Part 2 of ICEA S-68-516
      b. Strand screen: Extruded semi-conducting thermosetting compound applied over the conductor. The material shall be compatible with the conductor metal, shall be uniformly and firmly bonded to the overlying insulation, and be free of stripping from the conductor.
      c. Insulation: High quality heat, moisture, ozone and corona resistant Ethylene Propylene Rubber (EPR) compound
         (1) The insulation shall contrast in color with the strand screen and insulation shield per AEIC CS 6.
         (2) Insulation level shall be 133% (115 mils for 5KV, 220 mils for 15KV).
         (3) The minimum thickness of the insulation at any point shall not be less than 90% of the specified nominal thickness.
         (4) The insulation shall contain no more than 2% polyethylene.
      d. Insulation shield: Extruded semi-conducting thermosetting compound applied directly over the insulation. The material shall be compatible with the insulation and overlying metallic shield. The insulation shield shall be clean and free of stripping from the insulation and comply with Paragraph D.1 of AEIC CS 6.
e. Manufacturing process: The strand screen, insulation, and insulation shield shall be applied with a triple-tandem process providing a virtual corona-free core. The EPR insulation system shall not be exposed to the atmosphere during manufacture.

f. Metallic shield and individual jacket: .005 inch thickness of copper tape helically applied over the insulation shield material with a 20% overlap, covered with an extruded PVC outer jacket meeting the requirements of ICEA S-68-516 Paragraph 4.4.10.

g. Identification: The following information shall be surface-printed on the overall jacket: Manufacturer’s name, cable size, cable type, year of manufacture and voltage rating.

2. Armored cable

a. Single conductors: Per the section above. (Note: Individual PVC jacket shall be required for each single conductor).

b. Grounding conductors: Bare copper, stranded in accordance with ICEA S-68-516, Part 2. Minimum size shall be in accordance with UL 1072, Table 11A. (Note to designer: Provide a larger size, if required, to handle calculated fault current.)

➢ **IMPORTANT:** In the University of Washington primary distribution system the size of main primary feeders are 500 KCM. In instances where #2/0 cable is tapped from 500 KCM cable, to subfeed a facility or load, provide ground conductors in #2/0 cable equal to the ground conductor of 500KCM cable. Ground conductors shall be factory installed with the phase conductors and shall be an integral component of the cable. This is not an industry standard and shall be clearly indicated in the design documents. Supplemental grounding conductor external to the interlock armored cable is not acceptable by the AHJ.

c. Filler material: Non-hygroscopic material, fine fiber, completely filling center and peripheral interstices

d. Binder tape: Applied over assembly to provide a solid core

e. Armor: Galvanized steel or aluminum, interlocked armor in accordance with ICEA S-68-516, Part 4 and UL 1072, Part 25.11

f. Overall jacket: Polyvinyl Chloride (PVC) in accordance with ICEA S-68-516 paragraph 4.4.10. Industry standard color by voltage class (15kV cable – red; 5kV cable – yellow).

g. Identification: The following information shall be surface printed on the overall jacket: Manufacturer’s name, cable size, cable type, year of manufacture and voltage rating.

h. Listings: Finished cable shall be UL listed as Type MC, MV-90 and "For CT USE."

i. Color for outer jacket shall be consistent with industry standards.

3. Cable rejection

a. Cable shall be subject to inspection by the University at delivery and installation and subject to rejection for shipping and/or installation damage including, but not limited to, jacket penetration, armor denting, or other indications that cable integrity has been compromised.

b. Hi-pot and Megger testing will not be the sole determining factor in the Owner accepting or rejecting damaged cable.
2.03 SPLICES AND TERMINATIONS

A. Medium voltage

1. Medium voltage connections and terminations (armored cable and single conductor) - Long barrel, 2-hole hydraulic crimp lugs, with Raychem "HVT" or 3M "Quick Term" series 5600 termination kits

2. Medium voltage connections and terminations (armored cable and single conductor) - Long barrel, 2-hole hydraulic crimp lugs, with Raychem "HVT" or 3M "Quick Term" series 5600 termination kits.

3. Splices other than cold shrink are to be housed in a listed enclosure: OZ Gedney Series SPKJR, G&W #E74 or Adalet 3AS manufactured by PLM, with fittings to suit cable.

➤ IMPORTANT: Specifier to add Exact Requirements for Cable

4. Method of crimp termination for #8 awg and larger shall be performed with correctly sized hexacentric die only.
   a. Approved manufacturers: 3M, Elastimol; all other manufacturers shall be approved prior to bidding.

PART 3 – EXECUTION

3.01 REQUIREMENTS

A. General installation

1. Identification
   a. Reference section Electrical - Wire, Cable and Terminations

2. Qualification and Training
   a. Medium voltage cable work shall be performed by qualified and experienced personnel. Cable manufacturer’s representative shall provide training and shall oversee the rigging, pulling, installation, and termination of medium voltage cable.

3. Installation
   a. The installation of cables shall be done 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, side wall pressure, and minimum bending radius as given by the cable manufacturer shall be observed.

   b. Cable pulling
      (1) In no case will strands be removed to attach pulling eyes.
      (2) Tension is limited to 1000 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 side wall pressure shall be submitted.

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

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

c. Cable pulling setups and operations shall be witnessed by the University Physical Plant High Voltage Shop and Engineering Services.

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

e. 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. University will identify the West Receiving Station phase rotation convention.

2. System Phase Sequence is C-B-A.

4. MV switch phase terminations shall be A-B-C left to right when facing the front of the switch.

5. Junction box phase terminations are A-B-C left to right.

6. 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 2.4kV normal and emergency power system.

7. The Physical Plant Department High Voltage Shop 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 the University for the times when their services will be required, and under no circumstances shall the Contractor connect to the existing system without their 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 his own expense.

8. Install cable terminations per manufacturer's recommendations.

9. 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.

10. 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

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

12. All terminations shall be secure and tightened in accordance with the manufacturer's recommendations.

C. Mounting and electrical connections
   1. In accordance with manufacturer's installation instructions.
   2. Coordinate remote control and annunciation with the University representatives.

D. Training
   1. Provide operation and maintenance training for two 2-hour sessions of on-site training for a total of 6 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 ETC (Electrical Testing Contractor) per Section Electrical - Inspection, Calibration and Testing.

END OF GUIDE SPECIFICATION SECTION